TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS,

VOL. III.

MAY 18TH—19TH, AND JUNE 8TH, 1886.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Annual Meeting.

May 18th, 1886.

The meeting was called to order at 8 P. M., May 18th, 1886, by Vice-President Frank L. Pope, in the rooms of the American Society of Civil Engineers, 127 East 23d Street, New York city.

The Chairman: The first business before us this evening is the election of officers for the ensuing year. I will ask the Secretary to read the list of candidates.

The Secretary: The by-laws regarding the election of officers were amended and simplified at the meeting held December 7th, to read as follows: "Elections: The annual election shall be held in the city of New York, on the third Tuesday in May of each year. Nominations for officers may be made in writing to the Secretary at any time previous to the meeting, but the votes shall be by ballots deposited only by members actually present. *Provided*, that no member or associate in arrears since the last annual meeting shall be allowed to vote until the said arrears shall have been paid. If for any reason it is deemed proper to postpone the election, it may be adjourned from day to day with the consent of two-thirds present or voting. Referring to the terms of office—

Section IV provides: "The President, the Secretary, and the Treasurer for one year (and no person shall be eligible for immediate re-election as President, who shall have held the office subsequent to the adoption of these rules, for two consecutive years), the Vice-President, for two years, and the Managers for three years; and no Vice-President or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. At each annual meeting, a President, three Vice-Presidents, four Managers, a Secretary and a Treasurer shall be elected, and the term of office shall continue until the adjournment of the meeting at which their successors are elected."

It will be seen according to the by-laws, the President of the Institute, Dr. Norvin Green, is ineligible for the office of President, having held that office for two terms, and consequently the nominations for President will be first in order. There have been no formal nominations made.

THE CHAIRMAN: We are now ready to receive nominations for President for the ensuing year.

MR. MAILLOUX: I would like to make a nomination, and in rising to make that nomination I think it is proper perhaps to make a few remarks as to what the character of a nominee for President should be—what is the kind of man that we would like to have as a President. I have been connected with a few scientific and semi-scientific societies, and it has been my experience and my observation that a great deal of the success or non-success of an institution depends on the head of it. I remember some societies with which I have been connected that have been successful at certain periods of their life, and merely because they have had a man at their head who understood the nature of the position, who was so intimately associated with the objects of the association that he could see to the wants of it. I need not say, of course, that it is useless for us to have a President who is not a President except in name. I think after a few years of that kind of head-ship and leadership the society will suffer greatly. Now the man that I would specially favor—I have several names, all of which would be acceptable to me but there is one of them that I think ought to come first, a man who has won his spurs, as my friend Mr. Jones was just telling me; a man who would lend dignity and grace and force to the Institute, because he is so associated with electricity that when his name goes out as President of this Institute the whole electrical world will know him. I have reference to Mr. Frank L. Pope.

MR. PHELPS: I second the nomination very heartily.

I move further that the Secretary be instructed to cast the ballot of the association for the nominee. That will save the trouble of passing around the hat and cutting up pieces of paper.

THE SECRETARY: There certainly can be no objection to the election taking place now. It was my idea that if we went through these nominations and postponed an election until later in the evening, it would give a chance for others to come in and it could not be said that we finished up too soon for them. There are several other nominations to come up, and we might make all the nominations and vote on them afterwards.

Mr. Phelps: I will withdraw my motion.

The Secretary: There are to be three Vice-Presidents elected in the place of Messrs. T. A. Edison, George A. Hamilton. and Prof. A. E. Dolbear. It has been very properly suggested by our Treasurer, Col. Hazard, that although Dr. Green is inelegible for the presidency, it would be a very proper compliment to make him a Vice-President, and in the absence of Col. Hazard I would nominate Dr. Norvin Green as one of the three Vice-Presidents.

Mr. Phelps: I second the nomination.

Mr. Wetzler: I would like to put in nomination Mr. C. O. Mailloux.

The nomination was seconded.

Mr. Mailloux: I think that kings should come before princes always, and there are lots of other men who would grace the position much better than I. I am willing to wait until I grow a little. If I may be permitted to put a name in substitution I would nominate Mr. Frank W. Jones as Vice-President.

The Secretary: Mr. Jones is already a Vice-President.

Mr. Mailloux: All right. I will put in another one. I do not think there is a better name than Mr. T. D. Lockwood.

The Chairman: Do I understand you to decline the nomination, Mr. Mailloux?

Mr. Mailloux: Yes, sir.

Mr. Lockwood: It is rather an equivocal compliment of Mr. Mailloux to say that he resigns in favor of an older man, but since he qualifies that by comparing me to a king and is content himself to be a prince, I do not know but that I will consent to have my name placed in nomination.

The Chairman: There is one other nomination to be made for Vice-President, and I would suggest that as we have one from New York, Dr. Green, and Mr. Lockwood, from Boston, that it would be very well to represent some other part of the country, the South or West, in one of the other nominations.

Mr. Lockwood: Mr. President, I nominate Mr. George C. Maynard of Washington.

THE SECRETARY: I second the nomination. I was about to make it myself. There are three nominations now made for the vice-presidency. Unless some one wishes to run a dark horse for another candidate, that will be a sufficient number of nominations.

MR. LOCKWOOD: Will the Secretary be so good as to read the names of the Vice-Presidents who do not retire?

The SECRETARY: Frank L. Pope, who will retire if he is elected President, D. H. Bates, and F. W. Jones.

MR. MAILLOUX: Do I understand you to say that there will be another one if Mr. Pope is elected President?

The SECRETARY: There will then be another vacancy.

MR. MAILLOUX: I understood that there had been a movement to introduce some physicist into the chair of President, and although I was somewhat opposed to that, thinking that we should have a practical man at the head of things, still I have in mind several men who occupy professorships in the different colleges who would be a great honor to a position either as President or Vice-President, and above all I think we should not forget a man of the standing of Prof. Anthony of Cornell, and especially so from the fact that he is connected with the School of Electrical Engineering there. He is a man who has done a great deal for the science and he is a man who stands quite high, and if there is a vacancy I think it would be well to bear in mind that name before we take others.

The nomination was seconded.

THE SECRETARY: There are four Managers who retire at this election; Prof. Trowbridge, Prof. Gray, Theodore N. Vail, and W. D. Sargent.

MR. JONES: I would beg to nominate Mr. Mailloux as one of the Managers.

The nomination was seconded.

THE CHAIRMAN: We should have at least three other nominations.

THE SECRETARY: I am well aware of the importance not only of the Institute being represented in New York, but of its being well represented in New York, and when I say represented I mean actively represented. Such being a very desirable feature in a board of officers, I would respectfully nominate Mr. Sidney F. Shelbourne of New York as one of the Managers.

The nomination was seconded by Mr. Lockwood.

MR JONES: Will you have the kindness to have the list of Managers read that are not to retire.

THE SECRETARY: Charles F. Brush, Prof. Edwin J. Houston, Edward Weston, C. L. Buckingham, David Brooks, G. M. Phelps, Jr., Prof. B. F. Thomas, T. C. Martin.

I do not care to do all the nominating, Mr President, but there will be a gentleman here to-morrow, if he is not this evening, who took a good deal of trouble to attend our last special meeting and did most efficient work as presiding officer, and in his suggestions in the amendment of the by-laws. He is a man who stands high in engineering circles and a member of the American Society of Civil Engineers to which we owe so much. He is a man whose reputation dates back at least a quarter of a century. I refer to Capt. O. E. Michaelis of the Watervliet Arsenal at Troy, who I place in nomination as a Manager.

The nomination was seconded.

MR. SHELBOURNE: I nominate Prof. Brackett of Princeton College as a Manager.

The nomination was seconded by Mr. Wetzler.

THE CHAIRMAN: That completes the list of nominees equal to the number of vacancies. Of course we are at liberty to receive as many more as are offered.

MR. PHELPS: Is it in order, Mr. Chairman, to make a nomination for Secretary.

THE SECRETARY: Yes, sir. The Secretary and Treasurer are elected every year.

MR. PHELPS: Then I nominate Mr. Ralph W. Pope as Secretary.

The nomination was seconded by Mr. Lockwood.

MR. PHELPS: I do not think we can do better than re-nominate our present Treasurer, Mr. Hazard, and as I see no other nomination offered, I make that.

The nomination was seconded.

On motion of Mr. Jones, it was voted that the nominations be closed.

MR. PHELPS: Will the chair be good enough to have the entire list of nominees read.

THE CHAIRMAN: The Secretary will please read the list of nominations.

THE SECRETARY: The nominations are: For President, Frank L. Pope; for Vice-Presidents, Dr. Norvin Green, Thomas D.

Lockwood, George C. Maynard, W. A. Anthony; For Managers, C. O. Mailloux, Sidney F. Shelbourne, Capt. O. E. Michaelis, Prof. C. F. Brackett; for Secretary, Ralph W. Pope; for Treasurer, Col. Rowland R. Hazard.

Mr. Lockwood: I have a word to say before we proceed to any other business in regard to an observance which is followed in many other organizations of this character, as also in secret organizations. The one I have chiefly in mind is the analogous society, the London Society of Telegraph Engineers and Electricians. It is customary on the retirement of the President to place him on something like a retired list with the title of Past-President. I do not think there is any constitutional or legal provision for such an arrangement, but on the other hand I do not believe there is any constitutional or legal obstacle to it, and I think it would be a becoming honor not only for our present retiring President, but for any other who shall come after him, to give him such honorary rank and to place his name and title on the list of officers of the Institute in that capacity.

The Chairman: I think that is a very excellent suggestion of Mr. Lockwood's.

Mr. Jones; I quite accord with Mr. Lockwood's views on this subject. It had not occured to my mind before when we were making our Past-President a Vice-President. I think it is true that in some societies, both secret and otherwise, a man sometimes steps from the chair and becomes door-keeper; but this is hardly in that direction and it looks to me wise. It has worked well so far as the English society is concerned. I think that when the President retires that the year in which he serves the society should be printed in our journal and he should be classed as a Past-President of such a year, and as has been remarked there is no disability and no constitutional provision to the contrary and in the face of that I think we could carry that out. I approve of it.

The Chairman: It would probably be sufficient if are solution were passed authorizing the names of retiring Presidents to be printed as Past-Presidents in all the publications of the Society in which the officers names appear.

Mr. Lockwood: It might be well then, if it be the will of the society that some one, myself perhaps, as I made the suggestion, should draw up a written resolution and offer it to the Institute at the present meeting.

The Chairman: I think it would be be well to do that and when the other business is finished we could bring the matter up.

Mr. Shelbourne: I concur with the suggestion very heartily, Mr. Chairman, but in looking at it as a matter which involves a title in the printed publications of the Society it seems to me as a legal point that it ought to be provided in the by-laws that all Past-Presidents should be so named in the publications of the Society, etc. I only make that as a suggestion. There is that doubt in my mind about the propriety,—I mean the formal propriety, of adopting such a resolution without it becomes at some time a part of the by-laws.

Mr. Phelps: If it be in order to go on with the election, as I suppose it is, I would move now that the Secretary be directed to cast the vote of the Institute for the entire list as read. I believe that course is entirely proper where it is not objected to. It can be voted down if people object to it, and it saves time.

Mr. Jones: It has been suggested that if we are to fill the vacancy that is to be caused by Dr. Green's withdrawal, that steps be taken to re-arrange our by-laws so that in course of time Dr. Green can be placed on this list so as not so do any violence to our constitution. Perhaps the gentleman who has made the suggestion will make a motion to that effect.

The Secretary: Mr. Chairman, it does not occur to me that there is any violation of the by-laws by a resolution of this character. It appears to me that if a compliment is intended, that a special compliment in the way of a resolution to the retiring officer would be more proper than a compliment to which he was entitled by the regular routine of the by-laws.

Mr. Lockwood: That was entirely my idea. I had no thought whatever of, as it were, taking away the vice-presidency from Dr. Green. I think the Doctor is quite competent to be a Vice-President and a Past-President both at the same time. If the fact that he is a Past-President will render him ineligible for future office, I, of course, shall withdraw my resolution. I think he is quite competent to hold both offices and at the same time no by-law will be necessary.

Mr. Phelps: It had not entered into my consciousness that it was intended to withdraw Dr. Green from the list of Vice-Presidents and we ought to remember that this is a title and not an office. As it is not an office, in any sense, I think it is very plain that it is in order for us by mere resolution to authorize this title.

THE CHAIRMAN: I do not understand that this would render Dr. Green ineligible to office or affect that question in any way. Perhaps it might be well to suggest that the resolution might be offered in respect to Dr. Green personally and that at the same time the same resolution or another might be offered looking to the amendment of the by-laws or to an addition to the by-laws of a provision whereby all the ex-Presidents will be placed on the list of Past-Presidents.

MR. SHELBOURNE: There was no such idea in my mind at all that giving the retiring President a complimentary designation of Past-President would make him ineligible to office. It was merely a question as to the formality of such a resolution. It is true that while the by-laws say nothing about it, they also say nothing for it, and we are governed here by a constitution and by-laws. Of course if this is intended for the time being merely for a compliment to the retiring President, and such a compliment may or may not be paid to any other successor of the President, why then I should say that it was a mere matter of the present resolution, and it does not effect the question as to whether the by-laws do provide for it or whether they may provide for it. I merely made my remarks as casting out a suggestion and expressing a doubt without any view of formal action that I should have to propose in regard to it.

Regarding the motion of Mr. Phelps, as to casting the ballots for all the nominations by one as a committee, I would say that there seems a technical objection to that procedure so far as the nominee for President is concerned, because the nomination for one of the Vice-Presidents, I think, must necessarily be only contingent, and that nomination cannot stand or be acted upon until the President is formally elected. Therefore, I think, if Mr. Phelps would amend his motion so that a vote might be cast as one for the President and then afterwards, a vote for all the other nominations may be cast in the same manner.

MR. PHELPS: I accept Mr. Shelbourne's suggestion and would amend my motion by moving that the Secretary be instructed to cast the vote of the Institute for Mr. F. L. Pope for President.

THE CHAIRMAN: Before putting that motion perhaps it might be well to see what the provisions are in the constitution or by-laws in regard to the manner of election.

The Secretary: The constitution provides that elections must be "by ballot deposited by members actually present."

Mr. Phelps: It is open to any one to vote against such a motion, but where there is no objection I think it is perfectly proper.

Mr. Maynard: I should rather be inclined to object to this wholesale mode of voting. I think some of us would be beaten if the members had a chance to vote against us.

The Secretary: The ballot is considered rather a sacred affair and the general procedure is that every one should be entitled to make an objection. If the matter is open for everybody to object, each has an opportunity to object, and if done proceed individually to ballot. Otherwise, a unanimous vote will permit this method to be carried out.

Mr. Maynard: I agree with the proposition that the Secretary may cast the ballot of the society for any candidate, but I thoroughly favor that being done in the case of the President. If that motion is before the meeting I would second it.

Mr. Shelbourne: I move that we proceed to the election. I think a motion in this form would obviate objection and meet the suggestions that have been made: I move Mr. President,—if no objection be made,—that the ballot for President be cast by a committee of one to be appointed by the Chairman as and for all the persons present and entitled to vote.

The motion was seconded.

The Chairman: Do you offer that as an amendment to Mr. Phelps's motion?

Mr. Shelbourne: Mr. Phelps's motion, I believe, was with reference to all the nominations.

Mr. Phelps: I accepted Mr. Shelbourne's amendment a little while ago and confined it to the President.

Mr. Shelbourne: Then I make it as an amendment to Mr. Phelps's motion. The amendment was carried and the Chair appointed Mr Phelps as the committee.

Mr Phelps, as such committee, cast the ballot of the Association for Mr. Frank L. Pope for President.

The President: Gentlemen, I think it is proper for me to thank you very cordially for the honor which you have conferred upon me. It is one that I very highly appreciate, My only fear is that I am so unaccustomed to discharge the duties of an office of this kind, that I may fail in some particulars, but I will say that I will do the best I can for the Institute. (Applause)

We are now ready to proceed to the election of the remaining officers.

MR. WETZLER; I move that the Secretary cast one ballot for the remaining officers.

THE SECRETARY: I rise to make a personal explanation. In consideration of the fact that one of the same name and the same family has been elected President it may appear that there is rather an undue proportion of Popes on the list of officers, and I would suggest the substitution of some other name for Secretary in order that the criticism may not go forth that this is a family concern, as we have heard in some cases in regard to similar institutions.

MR. PHELPS; I think we will try to bear up against any insinuations of that kind that may be made. It would be unfortunate to have to deprive ourselves of the services of our Secretary for the past year on a ground of that kind, and we all know how carefully and efficiently the office of Secre'ary has been cared for by Mr Pope. I do not believe we want to swap horses now on any sentimental consideration

MR. LOCKWOOD: No man is a more profound hater of papal aggression than myself. Under the present circumstances, however, I think I am willing to forswear protestantism. The only possible reason, apart from the sentimental one given by Mr. Ralph W. Pope for objecting to take the secretaryship, or to our conferring the secretaryship upon him, is that he may be desirous of the more remunerative position of Treasurer. I think to transpose the secretaryship and treasuryship, in this instance would be very hazardous, and that we had better adhere to our original nominations.

MR. WETZLER: As the Secretary is one of the officers to be balloted for, I move that the Chair appoint a member to cast the ballot. Motion carried. The Chair appointed Mr. Lockwood as the committee.

The SECRETARY: Mr. President, the committee report the following ballot elected as the voice of the meeting: Vice-Presidents, Norvin Green, Thomas D. Lockwood, George C. Maynard, Prof. W. A. Anthony; Managers, C. O. Mailloux, Sidney F. Shelbourne, Capt. O. E. Michaelis, Prof. C. F. Brackett; Secretary, Ralph W. Pope; Treasurer, Col. Rowland R. Hazard.

Mr. Shelbourne: Following out the suggestion of the results of the discussion with regard to the Past-Presidents or retiring Presidents, and understanding that the view is that it is merely complimentary, I think that it might be as well to disperse the doubts which I cast upon the question. Therefore I move that the additional designation of Past-President be attached to Dr. Norvin Green's name as Vice-President in the publications and transactions of this Society.

Mr. Lockwood: I am much gratified at the reconsideration of my friend's point, but at the same time, since he has brought the matter up it seems to me it is better to do this by a formal resolution now, and in hat resolution it would be well to convey also to Dr. Green the thanks of the Institute for his services durthe past two years, and I shall, with the aid of my friend Mr. Mailloux, prepare a preamble and a pair of resolutions which I trust will pass.

Mr. Jones: I concur in Mr. Lockwood's view of the matter that it should come up on a formal resolution to express he thanks of the society, and when I make that statement, I think as a member of the Council it is also my place now to say, that Dr. Green has manifested a very kind interest in the welfare of this Institute. He has been at almost all of our Council meetings, has acted as the presiding officer, has given the benefit of his long experience and his far-sightedness and council in matters of great importance, and I know that the thanks which we are about to tender are doubly due to him. It probably was a little surprising to us all to know that he would, notwithstanding his many business cares come here so many times and manifest the interest that he has, so that in giving the thanks, it is not a mere formality at all, but I think one that should come with a good deal of heartiness from the members.

Mr. Shelbourne: I believe my motion was not seconded; therefore it falls entirely and leaves the matter open to the suggestions of the gentleman who has just spoken.

The President: While the resolution is being prepared, we will listen to the reading of the Secretary's report,

Secretary's Report.

In compliance with the rules of the Institute, a brief report is hereby submitted, embracing a period of twelve months, which in addition to a statement of the condition of the society, contains certain observations which should be considered in connection with our future work.

According to the report at your first annual meeting, there were 279 names upon our roll, and as this number has diminished to 250, it is proper that the circumstances should be stated in order to account for this decrease.

It appears that in the informal proceedings which led to the foundation of the Institute, a large number of names were suggested by different persons present as being likely to assist in sustaining a scientific society of this character. These anticipations were not realized in a large number of cases, and no responses to communications addressed to them were received, either by my predecessor or myself, which would indicate a desire either to join, or otherwise promote the welfare of the Institute. In order to ascertain the disposition of these gentlemen, a circular was prepared with the approval of the Council, stating the circumstances under which their names were enrolled, and requesting a reply as to their intentions. A very large portion of those addressed failed to reply, a few declined, while a still smaller number availed themselves of the privilege of being continued as charter members, and expressed their best wishes for the success of the Institute.

The cash receipts of the year were $975.25, which are accounted for in the appended statement. It should be borne in mind that owing to the nature of the Institute, the payment of dues must be wholly voluntary. That is to say, in cases where individuals must look carefully to their personal expenses, their obligations to the Institute are a secondary consideration, and for this reason it is extremely important that the usefulness of the Institute be promoted, in order that membership may eventually be of such practical value as to attract the support of all who desire to elevate the standing of the profession. This is by no means a new problem in association finances. The field to which our labors are necessarily confined, is also occupied by other organizations, some of which are of a special character, and are doing excellent work.

The revision of the by-laws which had been found necessary, was undertaken by a committee appointed at your last annual meeting, which reported to a special meeting held on December 7th, 1885. The amendments were then thoroughly discussed, a few changes made, and formally adopted. The plan providing for the transfer of associate members to full membership has not been put into operation as yet, and I am therefore not prepared to give a report of its practical working.

The question of providing permanent quarters is not fully settled, but the matter is in good hands, and it appears probable that some of the plans mentioned will be adopted. Perhaps the most promising at present is the proposition to secure accommodations in a new building now being erected on 23d Street near Sixth Avenue. A temporary office was occupied on Liberty street for a few months, but not being essential to the welfare of the Institute, it was relinquished, and the Council has since availed itself of the courtesy of the American Society of Civil Engineers for accommodations. The hospitality extended to the Institute since its organization by this Society, has been most heartily appreciated by our officers and members, and while we have no reason to believe that these privileges will be curtailed in the future, efforts should be made to secure a permanent home at the earliest possible date, in order that our members may feel that their anticipations of a vigorous and growing organization are fully realized.

A communication from the Secretary of the National Telephone Exchange Association is submitted herewith inviting the cooperation of the Institute in securing the general adoption of the new English Standard Wire Gauge. Such action has already been taken by the National Electric Light Association, and the introduction of this gauge is I believe looked upon with favor by manufacturers and dealers. As the management of the three leading telegraph companies is represented in this body, there appears to be a sufficient reason for the consideration of the subject at this meeting.

THE NATIONAL TELEPHONE EXCHANGE ASSOCIATION.

SECRETARY'S OFFICE, No. 234 BROADWAY.

New York City, Oct. 1st, 1885.

Dear Sir :

I am instructed by vote of this Association to notify you that at its annual meeting held in Providence, R. I., last month the New English Standard Wire Gauge was adopted as the official gauge of the Association, and to request the co-operation of your Society, (in such manner as it may deem most effectual), in an effort to bring about its universal use as a standard wire gauge in the United States.

The advantages of a standard gauge are so obvious as to need no expla-

nation, and it was believed by the Association that the above gauge, was upon the whole best suited for the purpose.

I would be glad to correspond with you further upon the subject.

Yours very truly,

C. H. Barney, Secretary,

To the Secretary of
The American Institute of Electrical Engineers,
11 Wall Street. New York City.

The importance of the various electrical problems which are continually being brought to public notice, points to the advisability of holding monthly meetings for the discussion of current topics. There are in New York and vicinity a sufficient number of members to make such meetings sucessful, especially if those who are capable, and have had ample electrical experience will perform their duty, in the preparation of suitable papers for presentation on such occasions. I can see no reason why such a gathering might not be held monthly in conjunction with the regular meetings of Council under existing arrangements. A suggestion of this kind was made by my immediate predecessor, but not having been acted upon, I feel it my duty to state that I consider something of this kind absolutely essential to the future prosperity of the Institute, and earnestly recommend that the matter be taken up at this meeting. If possible I should be glad to see at least six members or associates now appointed, who should in turn present suitable papers for discussion on such occasions. At least one meeting of this character might be held early in June and upon its success would depend the arrangements for future gatherings. I have already been promised a paper for this purpose, and it is very probable that gentlemen who could not comply with our request to submit papers at the present time will be glad to do so at a more convenient season. It also appears probable that if suitable arrangements were made for reporting the proceedings of these meetings, many important electrical papers would be brought before the Institute which are now presented to other societies, although perhaps entirely foreign to their special field. This is largely the result of a popular interest in electrical researches now existing, which we should avail ourselves of to stimulate the growth of the Institute.

With the inauguration of such a policy as I have outlined, your Secretary will feel far better satisfied with his work, and the existence of the Institute will gradually become more generally known, and properly appreciated by those for whose benefit it was founded.

Respectfully submitted,

Ralph W. Pope,

New York, May 18th, 1886. Secretary.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

SECRETARY'S BALANCE SHEET.

FOR YEAR ENDING MAY 18, 1886.

THE SECRETARY IN ACCOUNT WITH THE A. I. OF E. E.

Dr.		*Cr.*	
To Initiation fees (13).......	$ 65 00	By Cash to Treasurer......	$744 96
" Annual dues............	904 96	" Postage....	16 43
" Sales of Proceedings.....	3 50	" Books and stationery....	2 45
" Cash from Secretary Martin	1 29	" Packing and moving ...	5 50
" Stamp sold.............	50	" Office rent (two months).	25 00
		" Desk and chairs bought..	30 00
		" Services Jan., Feb. & Mar.	150 00
		" Balance on hand........	91
	$975 25		$975 25

Ralph W. Pope,

Secretary.

E. & O. E.

Mr. Phelps: I move that the report be received and placed on file.

Mr. Lockwood: With reference to the paragraph in which the Standard Wire gauge is spoken of, if I noticed correctly there was mention made that this gauge had already been endorsed by the National Electric Light Association. I think it should be amended slightly by adding the words "And the National Telephone Exchange Association." I mention this because that is the Association I believe which took the first official action in this country on that subject.

The Secretary: I should perhaps have read this communication before taking my seat, which would have explained the point raised by Mr. Lockwood. This signifies that it has been adopted by the Telephone Exchange Association and will be annexed to the Report of the Secretary. I presume that will cover your point. [The Secretary here read the communication from Secretary Barney.]

The motion of Mr. Phelps that the Secretary's Report be received and placed on file was put and carried.

The Secretary: I wish to offer a resolution if no other person is prepared to do so, to the effect that the American Institute of Electrical Engineers endorse the use of the new English Standard Wire Gauge and co-operate with the National Telephone Exchange Association and the National Electric Light Association in introducing it.

The President: I would suggest that as the endorsement of the Wire Gauge is a matter of a good deal of practical and commercial importance, perhaps it would be well if some one would offer a resolution looking to the appointment of a committee to examine the matter with a good deal of care before coming to a final decision about it. It is not a matter that should be decided off-hand. It is a question that the manufacturers are very much interested in as well as the consumers, and it would be a good plan to get their views about it.

Mr. Phelps: I move that the resolution as offered by the Secretary be referred to a committee of three or five to be appointed by the Chair, just to get the thing started.

Mr. Lockwood: I suggest five, Mr. Phelps, that would represent all.

Mr. Phelps: Yes, five; a special committee of five.

The Secretary: I had no idea of actually proposing a resoof that kind, but I would say, for the information of those gentlemen present who may not have attended the Telephone Exchange meeting and the Electric Light meeting, that in the first place the matter was very carefully gone over by the committee from the telephone association, and letters written to the various manufacturers of wire in this country, and that wire manufacturers were represented at Providence and took part in the proceedings, and at the subsequent endorsement of the gauge at Baltimore, although the examination into the subject was not as thorough as was the case in the Telephone Exchange Association, they understood how carefully it had been taken up, and consequently did not go into an exhaustive examination of the different gauges as they would have done if it had been an original plan. This matter was acted upon by the telephone convention last September, and endorsed by the National Electric Light Association at their meeting in February, and I fear that if it is referred to a committee and we undertake to go into it as they have done, it will merely bring us into the position of endorsing a thing that has actually gone into use, and so we will come in at the tail end, and say that it is all right after it has been practically adopted.

Mr. Phelps: I suppose it would be quite easy for such a committee to possess itself of the features of the investigations that have been made by the electric light people and the telephone people, by conference with them, to see just what the grounds are for the adoption of the new gauge. It would not be necessary for them to go over again all the work that was done by those associations; that might of itself be sufficient; but it does seem to me quite proper that some kind of examination should be made of the subject before we vote to approve the gauge.

The **Secretary**: I would say in reply to Mr. Phelps's suggestion that the information is very easily obtained. The published proceedings of the Telephone Association and the Electric Light Association, both of which I have, contain all the information necessary on that subject and the Telephone Exchange Association sends out this schedule of the sizes of the wire, and, I might add that the subject has also been very carefully gone over in *The Electrician and Electrical Engineer*. The matter has been tabulated and is in better shape to be acted on now than a year ago.

Mr. Maynard: The question is whether it would not be well to know the result of the investigation made by the Telephone

Exchange Association nearly a year ago. That is a thing that the committee might very properly ascertain. For that and other reasons I would favor the appointment of such a committee.

Mr. President: The question is first on the amendment, that the matter be referred to a committee of five.

A Member: When shall this committee report?

Mr. Phelps: At the next general meeting.

The President: I think if the committee reports at the next general meeting it will be in season.

Mr. Mailloux: Has anybody taken up that suggestion about the monthly meetings? It strikes me we ought not to let an important matter like that pass by. There is quite a sentiment in favor of that project in the body of the Institution, and I must say for my part that I favor it greatly. I believe in spreading the light all we can and keeping the Institute awake, and I do not think there is anything that could conduce more than monthly meetings to awakening a general interest in electrical matters, not only among the members but with the general electrical public. I know that abroad it is customary for societies to meet oftener than three or four times a year. You almost forget that you have been there after three months and forget acquaintances that you make. Then again the frequency of meeting should be made to excite interest in certain matters and perhaps to replenish the literature of electricity to a certain extent. People do not have time to write and elaborate their ideas and let others have the benefit of them, but if they have a chance to come together once a month or once in two months and exchange ideas, I have no doubt that the friction would have a tendency to benefit us all and keep us bright. In that way we would provoke discussion which is healthy for us all, and at the same time we are producing material that is subsequently published and is going to be beneficial. It will help to supply a long felt want in literature.

Mr. President: I think we will postpone that a few moments until this other matter is disposed of.

Mr. Jones: This is an amendment that is being put as I understand.

Mr. Phelps: No, it is a motion for a reference of the resolution which has been offered.

The President: The resolution was to the effect that the

Institute take some action in reference to the endorsement of the English Standard Wire Gauge, which has already been endorsed and recommended by the Electric Light and Telephone associations. Mr. Phelps's motion is that the matter should be referred to a committee of five, to report at the next meeting.

MR. JONES: Why I arose was to find out how far distant the next meeting would be, because to my certain knowledge the subject of wire gauges has been agitated for the last eight or ten years, and if I remember rightly you, Mr. President, wrote a very interesting article on it several years ago, and I think it has been bandied around from one side of the Atlantic to the other and finally the electrical people and the manufacturers in England took the bull by the horns and adopted a gauge. Now if we are to submit the matter to a committee and bring it up a year hence when the gauge is in universal use around us, I think we will be rather slow. At the same time, it may be that this society has not sufficiently informed itself of the merits of the new gauge to pass upon it very hastily. I am in a position where I don't know. I am neither a manufacturer nor do I use the gauge very much, but I have some general ideas about the gauge, particularly after reading your article about it. The idea was to simplify the gauge, not to have half a dozen, but to have one that was based on common sense, so that any one could use it. Now as we are going to have a meeting to-morrow, and this committee can report to-morrow, and we can put ourselves on record to-morrow, if we can bring the matter right up, we show ourselves sufficiently intelligent and have back-bone enough to get into the swim and say we endorse it, it would be much better than to put it off for a year and play the old fogy in regard to it.

The SECRETARY: I might add that the proceedings at the Electric Light Association were somewhat in accordance with the ideas of the gentleman who has just spoken. A committee was appointed to report at the next session. They held a meeting during the noon recess, looked over the proceedings and formulated a resolution to the effect that the association endorsed the action of the National Telphone Exchange Association and recommended to their associate members that the new gauge be printed in their catalogues, and where orders were accepted it was to be understood that if no gauge was mentioned the new standard gauge was the gauge. That was the way they did it. They reported at the next session; and if we can do that I think the action will be wise; but as it will be seen this letter is dated October 1st, 1885. It was presented to the Council, and the Council considered it a subject for the annual meeting and I so notified the Secretary of the Telephone Exchange Association. Now here is the annual meeting, and if we take up the matter and report it a year hence, why it will be a long time.

Mr. Phelps: When is your next meeting?

The Secretary: To-morrow.

Mr. Phelps: When is the next meeting after to-morrow?

The Secretary: A special meeting may be called by the Council at any time. There is no regular date fixed.

The President: It is probable that no particular objection exists among consumers to the adoption of that or any other gauge so long as they are certain what it is. It seems to me that the objections, if there are any to it, will mainly be looked for among manufacturers. There are some physical difficulties in drawing wire to certain gauges. It is well known that it is less difficult, in drawing iron wire for example, to draw it to certain gauges, to a certain special range, I will call it, of sizes, than others. Although I have never studied the matter of the English gauge very carefully, I have been led to suppose that it was an attempt to simply remove the inequalities of the old Birmingham gauge and make it uniform in its sizes, a certain percentage of increase, and yet adhere quite closely to the old gauge which was found a practical one for the manufacturers. We have here with us this evening Mr. Wallace who probably is more familiar than any of us with the manufacturers' side of the question. Perhaps he will favor us with a few remarks upon it.

Mr. Wallace: I never saw the English gauge. I do not know what it is. I never saw the new gauge.

Mr. Shelbourne: I inquired of one of the gentlemen present who I supposed had attended the annual convention of the telephone representators, whether the manufacturers of this country who draw the wire have got it in use or whether they have adopted it, and he could not inform me. As you have said, Mr. President, it is of considerable importance that we take hold of this matter, but is is suggested that the adoption by resolution of this gauge by the National Telephone Exchange Asssociation, by the Electric Light Association, and by the electrical societies of the country, would be the means of forcing this gauge upon the manufacturers.

While that is very true, yet as you have remarked, there are some physical difficulties in the drawing of wire and it is a pretty hard way to get a gauge adopted if it has to be forced upon the people who are to make it and use it. I think it is wise that the committee that is appointed should consider this matter as presented in the letters and papers that are before the Secretary and report to-morrow. But there is a question about this gauge as to what it is called. We have heard it here to-night called the English Standard Gauge. We have also heard it called the New Standard Gauge. Now has it any precise title, and if so, what is it? I should like to hear the Secretary make some explanation on that point as to what it is called.

The SECRETARY: The circular of the National Telephone Exchange Association calls it "The Standard Wire Gauge adopted by the National Telephone Exchange Association, September 8th, 1885," and in parenthesis—this is the English title I presume, from the length of it—"New English Board of Trade Standard Wire Gauge, legalized March 1st, 1885."

MR. SHELBOURNE: If that is the case, I would suggest that this society leave off all those additional words and call it simply "The Standard Wire Gauge."

MR. LOCKWOOD: I have been through this discussion twice and it is very curious to note the similarity of the arguments presented in all the Associations on the subject. I do not know but what in some of the Associations that I have heard talk about it some of the members were actuated by patriotism. I heard one gentleman in the Telephone Exchange meeting argue that because the Brown and Sharpe gauge was an American gauge we should stick to that whether it was best or not. I heard another gentleman say we ought to stick to the American gauge anyhow. It is not known in England by the long title the Secretary mentioned, but as "The Board of Trade Gauge." There were some dozen or eighteen gauges. Every manufacturer had a gauge which was right in his own eyes and the Board of Trade thought it was well to establish some standard, and even though it might not be the best it would certainly be better than the confusion which theretofore existed. As you suggest it is simply what was known as the old Birmingham gauge modified. The sizes are made to approximate more than they have done. One of the most pertinent arguments used at the Telephone Exchange meeting was that it was a step toward uniformity the world over, and as a step toward uniformity it was a wise step. It was said that the English certainly would not conform to our ideas and that therefore the best thing we could do would be to conform to theirs. As it has already been adopted by two organized electrical bodies of the country it seems to me it would be hardly worth while for us to go for a very extended period at least through the same investigation over again. What we do, or what we do not do, is of no great moment except to ourselves. What we do will either show that we fall into line with others, or will show that we are what are called in telephone central offices "kickers." Those of us who order wire or use wire can get manufacturers to understand that if we order wire of such a gauge we mean the Standard gauge. If we wish to stick to Brown and Sharpe's gauge, we can say we want Brown and Sharpe's gauge, and yet after all is said or done, any user of wire who wants wire of an exact size will continue to order by thousandths of an inch. I know I always do when I want it, specifying, of course, the resistance.

Mr. Mailloux: I think the last word said by Mr. Lockwood strikes the key-note of my own sentiments and I think those of every one who has to deal with electrical measurements. I think the grand millennium will come when we designate wire by thousandths of an inch as they do in Europe. This thing of knowing wire by a number and having it mean something like 1,175 mils is a very annoying thing. My memory is pretty good but it is not equal at all to compassing the sizes of wires in mils and the various figures that go with them. I think we should anticipate that to a certain extent. I should say before we adopt the Standard Wire Gauge, that we should see how nearly it comes to the great idea that Mr Lockwood and I both agree in of having the wire designated by mils—thousandths of an inch. I believe if a gauge was constructed on that principle, it is the kind of a gauge that we should look for. I do not care very much whether it is Brown and Sharpe's or British or Indian, provided it has those requirements.

Mr. Jones: With all deference to our brother member I do not think the subject of wire gauge is the one up for discussion. We are merely speaking upon a motion for the appointment of a committee. Something has been said about nationality. I think nationality has nothing to do with it. We might as well talk about getting up another law instead of Ohm's law, because

Ohm doesn't live here. It would be as reasonable to object to Kepler's law because Kepler was not a citizen of the United States. Now I think we ought to pass upon this resolution to appoint a committee to consider the action of our sister societies and when the report is presented, if there are any members who do not understand the subject they can have all the discussion of it that is needed.

The President: There is no reason perhaps why a committee should not be appointed to make some sort of report at the meeting to-morrow and either dispose of the matter to-morrow or continue it on a future day.

Mr. Jones: We are not obliged at all to abide by what the Committee shall dictate. We can pass the matter over your veto even, if you would like to try it on.

The **Secretary**: I believe the only question about this is as to the time when the committee shall report.

Mr. Jones: I move as an amendment that a committee be appointed as in the previous resolution and that it report to-morrow.

The motion was seconded.

The President. As the motion now stands it is on the appointment of a committee of five by the Chair to consider the endorsement of that wire gauge and to report to the meeting to-morrow.

The motion was carried and the Chair appointed as the Committee, G. M. Phelps, Jr., C. O. Mailloux, T. D. Lockwood, F. W. Jones and R. W. Pope.

Mr. Phelps: I dislike to appear as in any way shirking anything in respect to this question, having offered the resolution; but my engagements are such that I fear I shall have difficulty in attending the meeting, except for a short time to-morrow, and therefore I am afraid I shall not be able to be of much use in the matter.

Mr. Jones: I regret exceedingly that I have to get up and ask to be relieved. I would like to do everything I can for the Society, but the facts of the case are that my engagements for to-morrow and the next few days are such that it is impossible for me to do justice to the duties of this committee. I see some gentlemen here who are very conversant with the subject and very much interested in it and if you would do the kindness to the society and myself, particularly to the society, to relieve me, I would esteem it a great favor.

The President: Mr. Wallace, are your engagements such that you could not serve on the committee to-morrow?

Mr. Wallace: They certainly are. I will try to be here to-morrow but I cannot serve on that committee.

The **Secretary:** I will endeavor to provide all the information in the way of the Telephone Exchange and Electric Light Association reports, and also the table I spoke of, so that the work will be facilitated. It will be simply going over what has already been accomplished and printed.

Mr. Jones: If it is necessary I will lend my copies of foreign journals, which contain the reports and discussions on the subject.

The President: I think, Mr. Phelps, I will have to leave you on the committee and take the chance of your being able to help in the work. I think your suggestions will be of some value as you have had considerable to do with manufacturing in which wire is used. I suppose I will have to excuse you, Mr. Jones, as I know your engagements at present are very pressing. I will appoint Mr. Maynard of Washington instead of Mr. Jones. As the committee now stands, it is Messrs. Phelps, Mailloux, Lockwood, Maynard and Pope.

Mr. Lockwood: I am now prepared to offer this resolution, if the meeting is ready to receive it.

The President: I believe we are ready to entertain it.

Mr. Lockwood then read the following resolution:

Whereas: Dr. Norvin Green, the first President of this Institute, has retired, after filling the office for two successive terms:

And Whereas, he has during his tenure of office manifested the deepest interest in the success of the Institute, and has been unsparing in his efforts to promote its welfare and advancement:

Resolved: That the American Institute of Electrical Engineers is conscious of and fully appreciates the honor and dignity which Dr. Green has conferred upon it, and desires to recognize in a fitting way the earnestness and zeal which he has brought to the discharge of the duties of the office.

Resolved: That the thanks of the Institute be tendered to Dr. Green, and that as a mark of respect the title of "Past-President" be assigned to him, and that he be hereafter designated by that title in the records and proceedings of the Institute.

The motion was seconded by Mr. Phelps.

Capt. Michaelis: I do not want to appear in opposition to the motion. I believe it to be well deserved in every way. But I think at the same time, before we put it to a vote, we ought to consider it a little. I think it would be very well to put all our Presidents in that category. It is done in our American Society of Civil Engineers. I think the Institute has conferred whatever honor it could confer by electing the distinguished gentleman who has presided over it two years, and really I do not think we could strengthen the confidence and honor we have shown him by passing any special resolution. I do not know what more honor a society can do to a man than elect him two or three times as its head. I suggest that, with a view of avoiding possible invidious distinctions in the future. If we thank our first President we shall have to thank our other Presidents. Otherwise it will seem that the second, third and fourth Presidents have not rendered as meritorious services to the Society as the first President. I think they should always be known as Past-Presidents, for the simple reason that that is a mere statement of a fact.

Mr. Lockwood: The gentleman, I believe, was not present when we introduced this matter some time ago, but I might say here that he has stated precisely my intentions in offering this resolution. I think it is due to our Presidents that we should not only honor them by asking them to accept the office and perform its duties, but that after they have retired we should further honor them by conferring upon them a title without an office and to which there are no duties attached. I intend this moreover as a precedent, that not only Dr. Green should be hereafter termed Past President, but that the same title should be extended to every President of our Institute hereafter; and at the same time, as there was no such provision in the Constitution and By-Laws, I thought that it was eminently proper that this course should be taken, and it did not seem to me necessary that there should be any alteration. I trust that we shall pass these resolutions and that we shall hereafter be enabled to regard this as a precedent.

Capt. Michaelis: According to our Constitution, I think the gentleman could reach the same object without any loss of time by simply proposing a Constitutional Amendment, and under that motion the amendment could be considered to-morrow. I believe that can be done under our Constitution.

The Secretary: That was the decision last Fall.

Capt. Michaelis: So that if an amendment were offered to-night. that hereafter all Presidents of the Society shall be known officially as Past-Presidents we could act on it to-morrow.

Mr. Mailloux: It strikes me, Mr. President, that by providing it in this way we would be having a sort of made-to-order title. It figures more in the light of an honor. It is not provided for and yet it is a precedent established, and it is a part of the unwritten law which all society has to deal with. If the by-laws provide for the appointment of a man as Past-President his being designated as such becomes a mere formality.

Mr. Jones: There does seem to be this good feature about it, that if you are not compelled hereafter to follow the Constitution in putting Presidents on the list of Past-Presidents that you have a very good remedy against delinquent Presidents. If they do not perform their duties faithfully we can retire them in silence and not put them on the list. On the other hand by this method we will pay them the compliment of saying "Well done: we put you on the list,

The President: It is with a great deal of pleasure that I put this resolution to vote. I know how busy Dr. Green has been, how many calls there have been on his time, and I only feared when we elected him as our first President that he would be unable to devote very much time to the interests of the Society. But I think I can truly say that there is no person connected with the Society who has exhibited more interest and who has done more for its advancement than Dr. Green. I think that every member of the Society will take the utmost pleasure in voting in favor of this resolution.

The resolution was carried unanimously.

Mr. R. W. Pope: I know it is getting late and perhaps some of the members are tired, but I do not want to see the meeting slip away without taking some action on this monthly meeting business. I have no desire to see action taken on it merely as a matter of form. There are monthly meetings, and monthly meetings. The New York Electrical Society has monthly meetings, and with a larger membership than ours the meetings are not as well attended as they should be, and it is very often the case that meetings of this kind lack interest and for that lack of interest members do not come. If they came there would be interest and if there was interest they would come. This is a question that has been discussed I presume in every society that has ever been organized in New York City. But there is one thing about New York City that appears to operate against the success of evening meetings, and that is this gap which intervenes between office hours and eight o'clock. It is a good while to eat dinner in, and it is hardly sufficient time to go home and return in; I have talked to different members of the Institute about a plan by which we could meet at some down-town or up-town hotel, making arrangements for a monthly supper. If we stay we have to buy our supper anyhow. We could get the hotel to furnish a room for discussion, We could meet there at six o'clock and take supper or dinner, and the meeting could convene at half-past seven. We can all be there and get through the work in decent season. That would also give an opportunity for those who wish to dine at home in preference to remaining in the City, to go home and get back with the assurance that there will be a quorum when they return. I believe that by this means and by the appointment of one of our members to present a paper for discussion—not necessarily a very elaborate paper, but simply sufficient to bring up points for discussion, that we may have very interesting meetings. We stand very differently from some other societies. For instance, there is the Telephone Exchange and the National Electric Light Association—societies which are devoted to special branches of electrical work. They supply topics enough to bring half a dozen papers before a meeting on their particular branch; while we cover the whole field and consequently we have a vast range of subjects to choose from, and most of our members are competent to discuss many features of all of them. I merely present this outline as a matter for your consideration, for I believe it is essential to the welfare of the Institute that we should get together oftener than once a year, and become acquainted with each other and make our existence manifest. (Applause.)

Mr. Mailloux: I have already spoken on this, but as nobody else seems inclined to get up and support it I will say something again. I scarcely need do more than simply reiterate what I said before, to the effect that I heartily endorse the project. I believe that it is the best thing that we could possibly do, and I also believe that it would be the means not only of keeping up the little fire that is now burning in the shrine, but also of making it brighter, and I hope that all the members will see this matter in the same light, at least those who are resident members. I suppose that a very large proportion of the members of the

Institute are residents of New York, or the vicinity, and that a great many others who while not exactly residents live sufficiently near, so that they could make it convenient to come once a month or once in two months, so that all told I think we have enough to make a nucleus of quite an electrical gathering, one which would be a credit to the Association, while it would be the means of fostering knowledge, and as I said before of enriching the literature of the profession. At present, I may be forgiven for saying it, but nearly all the literature on electrical subjects of any importance comes to us from abroad. There they have societies which are well kept up, well organized and well maintained and all men of any note in electrical circles take a personal interest in the welfare of the organization. We have some of the best men coming forward with papers and giving lectures on the subject. The matter may not be absolutely new perhaps, but it is introduced in a new relation, which is just as good as if it were a new subject. Then in Europe we find that men are not so tied up to their own petty schemes. I will give as an instance a lecture given lately by Gisbert Kapp on Dynamo Electric Machines. Now Mr. Kapp is himself a maker of Dynamo Electric Machines. At the same time he undertook to give a review of the state of the art, and he did it very successfully and very ably, and in order to do that he had to go through the shops of other people, visit their establishments and study their work and study their facilities. Now that is something we could scarcely hope to see in this country. People are very jealous of each other's interests and it would be hard to persuade men to say anything about it themselves much less to let you look at what they are doing. Now I think that the American Institute of Electrical Engineers, by its monthly meetings, could do a great deal to wear off that spirit of suspicion which seems to be characteristic of nearly all electrical enterprises in this country, and in course of time we should find people more willing to come forward and drop their little mite into the sum total of human knowledge and in that way we would get to be a little better, a little franker and a little less conceited, which would be good for us all. So as you see there are more ways than one to look at the question and every way you look at it you can see it will be a benefit to each individual in particular and to the electrical community at large.

Mr. Jones: It is a remarkable coincidence that the great

Society of English electricians and telegraph engineers was first fostered by the civil engineers, who lent them their rooms and helped them in many ways. I believe that is about our position here to-night.

The idea that the Secretary has started of utilizing the early part of the afternoon or evening to gather somewhere—as many of our members reside across the ferries or some distance in the country is a good one. If they could meet at four or five o'clock then we could utilize our time. When we get through the strain of the day, to start in at eight or nine o'clock and get through at twelve and have to start for Elizabeth, New Jersey, perhaps at half past twelve, we do not like it, no matter how attractive the programme may be. Now this is a subject that I hoped would come up to-morrow I am sorry that I have to touch upon it at a time when you are all impatient to get away and I am the least able to do it justice of any in the room. But nevertheless there is this fact, if we can associate ourselves with some eminent societies like the Civil Engineers, and can give something substantial for room and care and light, it would be better to come here and have an hour's meeting and then adjourn right across the street and we can come back. As time passes on we can have our library and other things at hand, and we can have some electrical apparatus which you cannot cart back and forward to an hotel. Our Secretary's idea, in my mind, is splendid in the main, but a few little details could be arranged, I think, to better advantage, and it has been suggested that we postpone this subject until to-morrow morning.

The President: The discussion is an informal one. There is no motion before the meeting. I would say that our Secretary seems to have given this matter some little attention. Perhaps he can inform us as to what formal action is necessary on the part of the Institute. As far as this matter of dining together and arranging about a room is concerned, that is a matter that the individual members can do as they please about. They have the privilege of meeting here if they want to, and if they prefer to meet somewhere else they can make their own arrangements. All we have to consider so far as I can see is what authorization from the main body of the Institute is necessary so as to give the proceedings an official character.

Mr. Jones: I move that the subject of holding monthly meetings lie over on the table to be brought up any time to-morrow.

The Secretary read the clause in the Constitution relating to meetings.

The President: It seems to me from that, that all that would be necessary in any event would be for fifteen members to call upon the Secretary to have these meetings.

Mr. Mailloux: I think it would perhaps be the best way to have as many of the members of the Association as are willing to do so form a kind of compact among themselves by which they agree to a programme of this description and if they present a resolution to the general body of the Institute, by which they would seek official recognition in so doing, it strikes me that would be the best way, If there is no motion before the house I would like to move that the question be brought up to-morrow. Is there going to be any regular business at to-morrow's meeting?

The Secretary: It is not a regular business meeting but of course we can transact business.

The President: This matter can be brought up by you or any one else at the meeting to-morrow.

Mr. Mailloux: The matter should really not take much time if it is brought up in the shape I suggest now. I move that a committee of three be appointed by the Chair to consider the matter and bring in a suitable plan or project and report at the meeting to-morrow. The motion was carried and the Chair appointed on the committee Messrs. C. O. Mailloux, Ralph W. Pope and G. E. Phelps, Jr.

On motion of Mr. Phelps the meeting then adjourned.

General Meeting.

May 19th, 1886.

The meeting was called to order at 10:40 a. m., by the President of the Institute, Mr. Frank L. Pope.

The President: The hour set for the meeting was ten o'clock, but as the attendance is rather limited in consequence of the bad weather, we have waited a little while. I think, however, as we have much to get through with to-day, we had better commence. The first paper on the programme is a paper by Mr. Sidney F. Shelbourne, which Mr. Ryan will read. The title is "Underground Electrical Systems."

UNDERGROUND ELECTRICAL SYSTEMS.

BY SIDNEY F. SHELBOURNE.

I. Definitions and Principles.

There has been extended use, of late, of the word system as characterizing anything pertaining to construction for underground conductors. Thus he who has some form of box, or conduit material, or even a material in which to imbed underground wires is referred to as promoting "his system." Such misuse of terms is unscientific, loose, and confusing to the average comprehension. A *system* is "a whole plan or scheme consisting of many parts connected in such a manner as to create a chain of mutual dependencies and harmonious relations." An *electrical* system consists chiefly and primarily of a construction and arrangement of underground conductors, singly or in cables, connected with each other in lines of communication and so disposed *inter se*, or related to other material and space as to afford a harmonious and efficient electrical service for all uses. The conduits providing merely passages or ramifications of underground channels for the wires or cables, must always be considered a subordinate and minor part of the problem of underground electrical service.

The principles therefore which should control the preparation of this paper and the discussion upon it should be—(*a*), the exclusion of individual facts, materials and forms, except so far as they have a bearing upon the proper consideration and determination of systems of underground construction within the definition given;—(*b*) that prominent notice should be given to those elements which relate to the harmony of the different kinds of electric service when the conductors are assembled in conduits underground;—(*c*) the omission of details which must be essentially alike in all underground distribution, and on which the inventive mind has expended so much of sweating energy, as nipples, elbows, hand-holes, man-holes, separating bridges, insulating stuffing boxes, lead joints, and the division of lead covered cables, as well as the multifarious ways of connecting branch pipes and house wires. These minutiæ are better left to the obvious suggestions of individual promoters or the practiced skill of the finger and thumb electricians;—(*d*) the rejection from consideration, beyond a mere mention, of those pseudo-systems in which bare wires are buried in trains or beds of insulating material without the proper ceremony of even a pine box for conduit coffin. Such methods must be essentially vicious as to prevention of wire contacts, security of extraneous insulation, and the absence of consideration of dynamic induction as the chief element in the underground problem.

The French Government, 30 years ago, began its experiments in underground wires with this so called "solid system" and at periods until the present day we have heard of some new advocate of this "way" of burying the wires. So history repeats itself among the novices of science as in the recurring styles of hats and the bigness of bustles.

II. CONDUITS FOR ELECTRICAL SYSTEMS IN CITIES.

It must be understood that conduits, as here referred to, are confined to cities which admit of something like a *system* of underground conductors. A single channel under a country road or a suburban highway leading to the hay fields may be maintained with almost any material which presents a reasonable show of durability. In large cities like New York the conduit question requires more consideration because of circumstances more difficult and intricate. Here the question of material is important—(*a*), in the protection of the wires and cables from mechanical injury and the chemical action of fluids and gases permeating the soil; (*b*), in affording a means of harmony between the several classes of service, by aiding to shield the wires from the currents of induction; (*c*), in the promise of a permanent durability; (*d*), in the economy of money outlay and underground space.

A few facts will illustrate the first point. A company put down in this city, about eighteen months ago, two armored cables, each containing seven copper gutta-percha-covered conductors. For a portion of the distance these cables were drawn into 6-inch cast iron pipes, and have suffered no harm whatever. For the remainder of the way, the cables were laid at the bottom of an open trench in a layer of clean sand and then covered with blue-stone flagging of a thickness of 2 to 2½ inches, the trench filled with earth and repaved as before. On this portion of the line, at places, the gutta-percha insulation was softened and partially dissolved, under extraneous influences supposed to come from the pipes of water gas in the same street. The wires had become grounded through minute pin holes forced through the weakened insulation by the electric current. At one place on the same part of the line a pickman's stroke had split one of the blue-stone slabs and entering through the armor of the cables had denuded the wires of their insulation. Another company found recently in Wall-street that the insulation had failed in an electric light service, the superintendent of repairs giving as the cause, that a pick point had gone through the shell of a 2½-inch wrought iron pipe which had become partially corroded by some years of service. Such facts are probably recurring in this and other large cities, as to various underground pipes and constructions many times every month in which street excavations are permitted. If these conduits for electric conductors are to be made of plastic compounds and placed in the networks of other pipes underground in this city or other cities, where excavations and repairs are constantly going on, how long may such a conduit be supposed to escape the recklessness of an Irishman's brawn with a 9-pound pick above his shoulder. Public authorities have therefore wisely excluded earthenware and concrete pipes from general use under the pavements, because of this liability to fatal injury, among other dangers, by which the service they were intended to perform might become interrupted. As to the character of iron pipes, on the other hand, to be selected, it is a well known fact that the thickness of metal and the purity of the iron regulate the choice to be made. The thickness of the iron is made to increase in direct ratio to the diameter of the pipe, and the corrosion is found to be in the inverse ratio of its purity. Therefore a 2½ inch wrought iron pipe affords but a low limit of life under oxidation and an equally low resistance to injury by penetration as compared with a cast iron pipe six inches or more in diameter. It follows, therefore, that the cheaper the material the greater the durability. The telegraph companies who have put down wires in this country by their own methods have generally recognized these facts. An earthen, cement, or concrete pipe for a conduit will not allow of calking like ordinary iron gas pipes, so that the joints have to be formed solidly with cement or cognate materials, and the lengths are torn apart by expansion and contraction, and thus destroy themselves unless buried at a depth so great as practically to secure an equable temperature, which again largely increases the cost of original excavation and renders required repairs difficult and expensive. Every one acquainted with the tables of the ratios of expansion of different materials can easily calculate the effects of thermal forces upon materials whose melting point is found at such low figures as 150° to 200° Fahrenheit. The co-efficient of expansion between zero and the melting point in materials of this class must of course be inordinately large. Of wood as a conduit material but little need be said. Such a conduit cannot, with ordinary care and expense be made water and gas tight, and even if this were done, a pick-axe in habitual excavation would soon disqualify that condition. Therefore such a conduit usually exists as a blind sewer or a nasty "hole through the ground" in which insulation can rot at discretion if not protected with lead, and if so protected then the lead in turn is eaten away in the rain water drainage impregnated with ammoniates and charged with carbonic acid derived from street droppings and vegetable decay in the soil.

Under the second point (b) all electricians understand the facts as to metals acting as screens to induction when giving a circuit or escape, in mutual connection, or with the earth and interposed between conductors or cables in use. A metal conduit thus shields the wires or cables within it from the dynamic induction of the conductors in use in a conduit alongside of it, by receiving itself the induced current and conveying it away to the earth at some available point or points in its length. If two or three separate metal pipes or conduits are placed side by side but not in general contact laterally, and each furnished with conductors or cables of distinctive service, a most beneficial anti-inductive agency would be realized from such a disposition of material. A misapprehension, however, has arisen founded it is believed on an error promulgated in an individual opinion or report made during the sittings of some committees in 1883 and 1884, under a self-constituted general committee on underground eleectrical inquiry. The opinion was given further extension in the first report of the Brooklyn underground wire commissioners, by misinformation, as though it had been made the deliberate conclusion of the committee on technique, which considered and ordered printed the individual report of 1884. A modification of the same opinion was urgently pressed upon the New York commissioners in the Autumn of 1885 and during the early part of the winter just past. I refer to the statement that iron conduits have the effect *to retard* the currents in the conductors within them. The theory on which such an effect is claimed has not been stated nor can such a proposition be assumed or proven from the facts. The theory of static induction and consequent retardation when precisely stated and referred to practical examples can give no ground for such a notion of the effect of iron as a conduit material. The idea can only be referred, for probable truth, to theoretical considerations of the effects of dynamic reactions due to magnetic influences.

The third point (c) has already been touched upon in speaking of the character and purity of iron as determining its durability. There can be no dispute that hydraulic cements or bitumen and cognate hydro-carbons either singly or combined with other inert substances if considered as *materials* are more durable than the commoner metals; but the question is not of the durability of materials *as such* but of the permanent character of the *construction* as a useful form of conduit into which the materials enter.

The commonest and cheapest sort of cast iron six inch conduit tube the metal of which has a thickness of three-eighths to one-half inch if boiled in a preserving bath, as is now done, and avoiding a salt water soil, will doubtless give continuous service for 40 to 50 years. Materials less strong than iron are exposed to the liability of damaging and breaking strains from the sagging of suspended lengths during undermining or contiguous excavations; the continuous line of plastic lengths and solid though weaker joints in conduits of mastic concretes cannot resist the forces due to changes of temperature, since there is no mechanical provisions for expansion and contraction and the solidly adhering parts must give way. Such materials too are exposed to the softening and warping or collapsing influences of heat from the steam pipes, and the constant danger of ruin from the implements of excavation.

Of the strength of cement and glazed and unglazed earthen ware pipes many of us have had practical observation in the number of pieces which have been found chipped and broken merely in handling and transportation from the factories to the points of delivery. It has been found necessary therefore where such materials have been used for conduits for underground electrical conductors that they should be made so solidly and therefore so bulky of material that the openings or spaces left for the wires can bear but a small ratio to the total section of space required for the body of the structure. Hence we are met again with the question of expense for bulk of material and, more important, the essential room or trench which must be assigned to such structures under streets already variously lined with pipes of the several uses and at such random levels and make-shift positions as to render it quite impossible to lay out a line of regular construction. But such cements and other plastic compounds have been selected for electrical conduit materials for another reason.

It has been thought convenient, and until recently even necessary that conduits for the wires and cables should be made with a series of holes or passages through a body of material so as to allow of a division or separation of the cables into the different longitudinal channels or compartments thus formed, and that a metal could not be cast into such a form of conduit with money economy, nor properly and securely connected together in one contiuous length The reason for this leaning of favor is drawn from the settled experience that heavy conductors and cables in considerable lengths cannot be drawn into a single passage conduit in succession the one on the top of or alongside of the other because of the friction and the interference of movement between them. Hence a conduit body of plastic material has afforded the most convenient means of securing a considerable number of individual passages separated by walls or partitions in the material itself, so that each cable or assemblage of wires may have its hole or passage in exclusion. The English Post Office Department however has preferred to use separate small iron pipes instead of the pigeon hole structure, some of them of three inches of diameter into which 80 wires bunched together are drawn at one operation. In this country such plastic body conduits have been made to some extent, containing from three to seven channels for the wires of a diameter up to 2½, 3 and 4 inches.

Such structures must be additionally very wasteful of space, besides the room required for solidity and strength of materials; for, if each passage can contain but a single cable or its equivalent of bunched wires, two-thirds of the wire space itself must probably remain unfilled by the cables. Had inventors sooner directed their energies to finding efficient means of drawing the cables and conductors successively as wanted for use, without injury, into compact position within the same tube or conduit channel of simple and cheap construction the question of how to find room for the wires under our streets would, ere this have ceased its bothering in the direction of multi-channeled concrete conduits and their pretentious promoters. But the interest in conduits of such a construction has been kept alive and stimulated by the plausible idea that each company now using overhead wires could have its own pigeon hole or compartment in a compulsory underground service. It has not yet perhaps occurred to all of us that if each company or party using wires is to have but a single compartment channel how many it would require to serve even present existing interests without a single thought for the future. But such a limitation would not answer the requirements of existing *companies* which use already a large percentage of the wires now overhead. If therefore on the other hand each or any company should be allowed to occupy the service channels *ad libitum*, how many vacant ones would the prominent existing companies be likely to leave for prospective rivals? The question of space, therefore, and control of such a conduit under our streets becomes one of the greatest importance, outside of the question of cost and durability to say nothing of the fact that conduit materials of an insulating character, have no agency, like a metal, to obviate the effects of dynamic induction.

It remains to notice the even grander suggestions of abortive genius in appropriating the sub-pavement spaces for the wires. The pravailing notions of a "sub-way" are without sense or practical calculation, and the word, with the notions attached to it, has unwisely been thrust into the legislation of this State as to underground wires. The general conception is that a "sub-way" must be a large viaduct or passage underground, like the Paris sewers or the Harlem Tunnel, and the idea for electrical conductors was evidently borrowed from the Paris sewers. Such constructions may be used if existing, but are out of the question as prospectively considered for electric uses. And yet would be inventors have loaded the rooms of the electrical service commissioners for this city and Brooklyn with drawings and models, the practical adoption of which would require a space of 10 to 100 square feet of vertical cross section, and a cost of $50,000 to $200,000 per mile. Even if such subways were practicable as to space and cost they would still fail to meet the requirements as to inductive harmony of the wires ~~within them~~, while to allow the various companies to occupy them pell-mell with their different uses would be the culmination of a stupid folly. We may therefore dismiss a "sub-way" as thus conceived from the room of this paper.

The question of necessary first cost, for the same useful capacity, as between multi-channeled concrete, and a simple cast-iron pipe conduit, need not be attempted here, because, at best, hypothetical calculations for electrical service underground must be uncertain and of speculative value by reason of the varying conditions of the service proposed and the locality designated. We must therefore begin and stop at first elements. It is enough to say that cast iron pipe conduits as made in dry sand, and for the usual sizes, cost from one and a half to two cents per pound, while if the conduit be made of box castings with plates and shelves, which are required to be moulded in green or wet sand, the cost per pound will be 50 to 75 per cent greater. Concrete may be made of a weakness or strength, within its limit, depending upon the will or honesty of the contractor, whether of hydraulic cement or an asphalt and coal tar basis, and the cost will vary in proportion.

III. Specific Inductive Capacity—Induction—Insulation.

No one has yet been able to tell us why it is that induction takes place through one kind of insulating material more readily than through another, any more than why, in the nature of things, copper should be a better conductor than lead. The essence and mode of electricity itself must perhaps be brought to demonstration before these questions can be answered. But it is clearly an experimental fact that inductive capacity of insulating materials has no immediate relation to quality as insulators. The table of substances experimented with shows a considerable irregularity and a remarkable variation in inductive capacity, ranging from 1.77 to 5 in comparison with the standard unit of dry air. The writer is led to speak of inductive capacities of insulations by the confusion which has arisen from the lack of proper distinctions in telephone service, between what is apparent as due to the conditions of static and dynamic induction respectively, and also because of the claims which have been made as to the merits of some of the underground cables.

It has come to be a tenet well received among electricians that "the better the insulation the greater the induction." This is particularly true of dynamic induction, as is well observed on telephone air lines in the difference between a wet day and clear, dry weather; but it is not altogether true as to static induction as one of the practical difficulties of electrical communication, for we have the example of a rubber insulation giving a much greater static induction than a high class of gutta-percha, and it has been the boast of some of the English manufacturers that they have increased the insulating quality of their gutta-percha and at the same time reduce its specific inductive capacity some 20 per cent. In this country a claim has been made that by reason of the low specific inductive capacity of an insulation used, an anti-induction cable is secured, (evidently referring to dynamic induction,) while the insulation itself is claimed to be very high up in the megohms. Let us examine the possibilities of this claim. In the first place, dry air is the standard to which all insulations are referred as well as all inductive capacities of their materials. We have seen, secondly, that dry air insulation is more favorable to dynamic inductive effects than damp air, and as the lowest known inductive capacity of solid insulation is 1.77, as compared with the unit of air, the claim is a fallacy as to dynamic induction, but as to retardation, the result of static induction, the claim is true, because long since proven by the insulations used on the conductor cores of the ocean cables. It follows, therefore, that the claim is mixed with both merit and demerit. It should be founded upon a low specific inductive capacity and a *low*, but permanent quality of insulation. But even when predicated of static induction the claim is of less importance than other considerations in the case of subterranean cables consisting of many conductors together in the same general body of insulation. For example, if we have given a lead-covered cable composed of many small telephone wires in a body of insulation comprising their individual insulations and a general inclusive insulation whose diameter inside the lead may be an inch and a quarter, then, if a wire be selected for use at or near the centre of the cable and the others are not connected through instruments or directly with the earth, the conditions would be most favorable for a low static induction in the use of that one wire. If some or all of the other wires were connected with the earth the static induction would be increased in inverse ratio of the distance of the earth wires from the wire in use. If, instead of using the wires in such a cable as ground circuits they should be formed by pairs or quadruples into a cable of strands and used as metallic circuits, the best invariable conditions of a favorably low static induction would be secured, aided, of course, by the low inductive capacity of the material of insulation and varied also inversely by the insulative quality or the amount of leakage indicated. But in cases of static induction, leakage and induction tend to the same disadvantage, because the greater the leakage the longer the time of charge, although the leakage to its extent, counterworks the static induction. Premising the conditions to be single insulated conductors in wet earth or water, the elements which determine static induction are four: the surface area of the conductor; the thickness of the insulation, or its exterior surface, which will vary in direct ratio in round forms; the insulation quality; and, lastly, the specific inductive capacity of the material of insulation.

While it is true that the specific inductive capacities of insulating materials have been experimentally determined alone in their relation to static induction, yet, if we may believe or assume that both static and dynamic induction are referred to the same source or origin in the nature of electricity and stand for the modes of its energies, there is no reason to deny, so far as any promulgated experiments are known, that insulating materials may not have a like capacity with relation to dynamic induction. At least we shall here assume the fact to lie in the majority of probabilities in favor of such a capacity. So that, as to dynamic induction between any two conductors insulated from each other, the elements are: the quantity and intensity of the current; the distance between the lines of average of parallelism of the conductors; the character of the insulation or the leakage *between the conductors;* and lastly the specific inductive capacity of the insulation.

Dynamic induction acts by laws and under conditions as invariable as the forces of gravity and yet we find repeated again and again the experiment of simple parallel wires bunched in cables and used for short distances with fair success, when at once the happy self-styled inventor rushes into print with a certificate from a climbing electrician, and the word "anti-induction" in heavy block capitals.

Of insulations but little need be said, because the subject is hackneyed of words. The whole list is good—better—best, and every new man can give us the best, because, he says, God has made him the Mahomet of a new revelation. Gutta-percha and caoutchouc are well known and long tried. For salt water, gutta-percha is unexcelled, but for underground lines it becomes hard and cracks and is subject to peculiar influences of decay, often of local and undetermined character. Para rubber of low vulcanization is better for underground work, but costliness excludes it from general use. The great cost of these chief insulators early led investigators to seek for substitutes. The lists of hydrocarbons were explored. Prepared bitumen and coal tar were brought into use and combined with other substances, mineral and vegetable. It is a fact as old as the cyclopædias of our day, that vegetable oils heated with a proper percentage of flowers of sulphur added at a limit of temperature, will become tough and elastic, yielding an artificial caoutchouc. This property has been made the basis of many of the patents for new insulations, the claims of which relate mostly to manipulation and proportion of constituents. The longest known "ites" are of this class. Other insulations are derived principally from the material of worn-out rubber boots and the scraps and bits from the rubber factories. Some of these also add to the "ites" a necessary toughness or elasticity. The fundamental process is simply the maceration and softening of the old material in oil of turpentine, and the separation and use of the available portions. Those insulations which have to be put on the wires by means of press and dies must always be considerably expensive for materials and labor. Then, too, some of these insulations are easily affected by ordinary weather temperatures. Copper wires have been known to drop by gravity through their gutta percha insulations when lying supported, simply by the softening of the insulation in summer heat. The steam pipes in this city would bring havoc to such insulations of homogeneity, softening at a low temperature. This fact has become so well understood by the experience of one of the companies that an injunction is in force, at this writing, restraining the Steam Company from placing its pipes in the vicinity of wires previously laid.

An insulation for underground wires should secure the copper conductor invariably in a central line within it. It should contain no elements of chemical change or deterioration as an insulator. It should be cheap, easily applied, and not liable to injury in manipulation after it has been applied. A low insulation permanently maintainable is the best for short lines and local service. Such an insulation with large sized copper conductors was among the first propositions laid down by the writer some years ago. In the Autumn of 1884, an experimental piece of underground telephone plant was put down in this city, in which the immediate insulation of the wires was cotton fibre in loose braidings on the wires which were then steeped in a hot bath of linseed oil. The insulation at first was very low, the best of it not giving per mile more than one-third of a megohm. In January, 1886, further tests showed that the insulation had so improved that the lowest gave a mileage resistance of one megohm, while the highest ran up to *seven* megohms. The writer ascribes this improvement to the slow oxidation of the oil into a thick gum of higher insulating quality than the fresh oil. It is maintained, as the result of experience with insulating materials, that a permanent insulation of from 50 to 200 megohms per mile is easily and very cheaply available for underground lines in which cotton fibre forms the basis of attachment or the vehicle of the prepared insulation.

IV. PROTECTION FOR THE INSULATION.

As long as the expensive and homogeneous insulations were almost exclusively used, their capability to exclude moisture for a long time rendered further permanent protection scarcely desirable. But the multitude of wires and cables brought into being by the progress of the telephone, called for the economy of cheaper insulations which required a durable extraneous protection. Even for aerial lines a light lead pipe, containing a large number of small wires, has come into extensive use. The tendency to adopt a lead jacket or covering for underground cables in the last five years has become almost universal, and only the older telegraph companies still adhere to homogeneous insulations and gummed taping for outer wrapping. The lead method thus far has been somewhat primitive and imperfect. At Philadelphia, in 1884, lead protected wires were exhibited, in which the thickness of the lead on one side was twice as great as on the other, and many productions of lead covering of the roughest exterior have been sold to telephone companies, with the insulation loose within the lead, and the shape of the finished cable neither round nor of any other ascertainable contour. Lead pipe coverings and lead press jackets put on thus loosely and unevenly are radically bad, since they do not exclude the air from the insulation, nor give assurance, therefore, against decay and deterioration. The perfection of the lead process is to be able to force the lead, while cold, close down upon the surface of the insulation and, without injury, sealing up as it were, the insulation within a uniform thickness of metal having a round and smooth exterior surface in the finished cable. Such a lead covered cable, with a well considered insulation, and barring accident and mechanical injury, would afford a guarantee of permanency for indefinite years of the future.

V. NEW DANGERS, OR WATER GAS AND "WHAT IS IT"?

Reference has already been made to the solubility of gutta-percha insulation in cables exposed to the soil without conduit protection underground in this city, by some agency supposed to come from water gas. The first suggestion was that it was the naptha used in the manufacture of that gas. This must be an error, because the naptha does not exist in the gas in the form of *vapor*, but is decomposed in the manufacture and yields two distinct *gases; i. e.*, light carburetted hydrogen, $C H_4$, and olefiant gas, $C_4 H_4$. From the best judgment which can be formed without actual experiment it is probable that one or both of these gases are capable of attacking the hydro-carbon insulations, since these gases themselves are cognate members of the hydro-carbon family.

But a more surprising apparent observation comes from the Brooklyn Commissioners for underground wires, in which it is alleged that water gas or some constituent of it will act upon metallic lead so as to convert it into the carbonate or white lead of commerce. The writer has taken pains to investigate this question both on his own effort and through an analytical chemist. The theory of such action necessarily requires the exhibition of carbonic acid gas. Water gas contains the merest trace of it, since, as a deleterious constituent, it is carefully eliminated in the manufacture. But to supply this for the lead attack it has been surmised that the monoxide, $C O$, of which water gas contains from 25 to 30 per cent of its volume, presumably undergoes after its escape from the pipes into the soil an additional oxydization and becomes the dioxide $C O_2$, or carbonic acid. This is an extreme improbability since it is known that the general action of soils is de-oxydizing rather than aiding to a higher oxidation, except under peculiar conditions in the presence in the soil of vegetable charcoal, and even in such cases the action is limited and insignificant. But why go in search for an explanation to the water gas pipes, when a known one is of ready suggestion. The Brooklyn conduit was a wooden box, admitting fresh water surface drainage impregnated with carbonic acid and ammoniates from the street manure and the decaying vegetable matters in the soil. Cold rain water will absorb a volume of carbonic acid equal to its own, while the monoxide from the water gas is scarcely absorbable at all. We have therefore the conditions of a ready action upon lead as will appear from the memorandum of Mr. Lucius Pitkin, analytical chemist, here following.

Memoranda on Corrosion of Lead Pipes in Ground from Leakage of Water Gas into Soil from Gas Pipes.

1. There are present in the soil under the streets of a city like Brooklyn, where from traffic a considerable amount of organic matter is present on the surface, the organic acids resulting from their decomposition. I mention:

(*a.*) Crenic acid.....	Watt's Dict.,	Vol.	II.,	p. 103.
	do.	do.	VII.,	p. 393.
(*b.*) Apocrenic acid..	do.	do.	II.,	p. 103.
(*c.*) Humic acid....	do.	do.	VIII.,	p. 1043.

Experiments by Simon point to the conclusion that humic acid renders ordinary calcium phosphate soluble, showing thus considerable solvent action.

2. Parke's Text Book, Am. Ed., p. 16, states that the action of water on lead is great in those containing organic matter, nitrates, and, according to several observers, chlorides. These would occur in the soil water of Brooklyn from soakage and decomposition from surface.

3. *Medlock* attributes the greatest influence to ammonium nitrite formed from organic matter. Lead nitrate is rapidly formed and carbonate is then produced, the nitrous acid being set free to act upon another portion of lead.

4. The amount of carbonic acid contained in the air of the soil normally is high where the conditions are as in a city street.

"In some rich soils the amount contained in the air present in their interstices is 250 times greater than the ordinary atmosphere ratio."—*Bassingault.*

"The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes more largely impregnated with this gas when it sinks beneath the surface."—Wilson's Hygiene, page 141.

In view of all the above causes present in the case, the amount of action due to any ordinary leakage from gas pipes containing the small percentage they do of carbonic acid, is practically nothing under the conditions stated by you.

LUCIUS PITKIN, PH. B.,
To S. F. SHELBOURNE, Pres't. Chemist.

Prof. Silliman says: "Lead is acted upon by distilled water and by rain water. Water, by reason of its affinity for the oxide of lead, acts like an acid upon metallic lead. A bright slip of pure lead is tarnished almost immediately in pure water, and after a short time becomes covered with a pellicle of carbonate of lead."

Whatever may be the true explanation of the formation of the lead carbonate in the Brooklyn case just stated, the argument from the facts would be that those cables should have been placed in iron or other conduits, excluding both water drainage and gas, so that no corrosion of lead could have been possible.

VI. ELECTRICAL HARMONY OF USES.

It follows from what has been said of parallel wires and dynamic induction that to harmonize the use of the heaviest currents for light and power, with the feeblest for the telephone, something further must be provided than underground possibilities of distance between the conductors. It is stated that with the present ærial spaces between them it is impracticable to work the telephone lines on lower Broadway after nightfall because of induction from the arc light conductors on the opposite side of the street.

There are two possible ways to harmonize the uses of the wires. One by induction screens forming circuits with themselves, or with the earth; and secondly, by a scientific arrangement of the conductors themselves in relation to each other and with reference to the different uses. These two methods may be combined with each other, and when so combined the best possible conditions of harmonious use will be realized. Metal screens may be so placed and associated as to protect individual conductors in relation to each other, or classes of conductors as between the classes. These provisions may both exist together, i. e., both screens for the individual wires and for the groups or classes may be combined in the same examples of construction. This may be done with the individual wires in ground circuit, or, better still, with metallic circuits for the trunk lines between the exchanges, operated in connection with ground circuits for local wires of short distances and deviating direction.

With reference to arrangement of conductors, here also two possible methods are admitted, though one of them rather belongs to the theoretical than the practical phases of the question. Theoretically, and with sufficient space at command, electric light circuits may be placed with their limbs parallel and separated from each other in the same general line of sub-way or conduit space and the telephone wires brought alternately for equal lengths within contiguous relation with the one limb and the other by crossing at regular intervals. Practically, with many wires of different uses, such an arrangement could not be economically available nor in any case can it afford a protection against dynamic induction between wires of the same class, which are usually in the closest assemblage in cables underground.

The single practical arrangement therefore of the wires is to arrange those of each class anti-inductively, when necessary, between themselves and then in the same manner as between the classes. This can be done with rigid economy of space by laying up the smaller wires in proper strands within cables, instead of parallel singularity, and by joining the limbs of the electric light circuits in fixed unity of relation with each other where ground circuits are used for the telephone wires, but where the latter are formed in metallic circuits, within cable strands, the electric light circuits may be used in straight-away or single limb lines presented to the telephone conductors, without inductive disturbance. It is reported that in exhibiting the Chicago underground wires at the beginning of the past winter a considerable stretch of telephone wire underground in connection with some miles overhead, and in ground circuit, was used successfully though passing underground for some two or three blocks parallel with and near to the underground electric light conductors then in service. It was not proclaimed, of course, that the two limbs of the electric light circuit were in the same conduit and probably exactly equi-distant from the telephone wire, for such a declaration would have been fatal to the object of the exhibition.

The whole problem of harmony of uses is of easy solution upon scientific principles well understood among electricians who have given attention to the subject, so as to make *a system*, as such, not only possible, but economically practicable.

VII. What We Have Come To.

The subject assigned to the writer by the Council and formulated in the caption of this paper is "Underground *Electrical* Systems." Can it be possible that we have been writing thus far without anything existing to write about? It seems to be so. If we look about the world for "Undergound *Electrical* Systems," we can find none. Somebody has referred to the underground conduit and cable work in Chicago as an "embryo system." It can hardly be classed so far in advance as that; it must be *conceptive.* And yet there is a quarrel between Chicago and Boston as to which stands first in underground honors. Before this dispute can be settled, Brooklyn expects to canter forward as a dark horse and reach the reward offered, of a clean looking city. But Brooklyn has yet to nail up her boxes for four-fifths of the work promised, to say nothing of the cables to line them. Even in that inchoate achievement, under legal provision and supervision, there are no assurances, as yet, of any attempt to secure *a system.* The heavier and inductively hurtful uses of electricity which present the seemingly difficult elements of the problem have, thus far, been left in abeyance.

But while this paper has not been able to treat of the happy success and details of existing systems, it is to be hoped that what has been written will open more clearly to the thought of electricians and other students of science, and to legislative and popular comprehension the elements and the conditions, both legal and practical, which should be brought into action in *creating* "underground electrical systems" for the future. As has already been noted, an electrical "system" must combine the *electrical uses* so as to secure mutual harmony in the general service. The various companies have heretofore, in all the cities of the country, whether by law or self-will, put underground each its own wires in its own way, and for its own special advantage alone. Could any one expect harmony of uses in such a state of things, or could *a system* be hoped to exist under such conditions of diverse individual purpose and action.

VIII. Conclusion.

A summary of the facts and considerations advanced will lead to the conviction that no underground electrical systems will be realized in this country until the several cities in which the overhead net works have become a nuisance awake to a conception of their public rights and duties as to underground wires. It is very clear that the individual companies, pursuing their own interests, especially where valuable patents and monopolies are still for a few years at their aid, will seek strenuously to extend and establish those patents and monopolies by occupying the spaces under the streets with their own wires in their own way, so that both the wires and the spaces shall enlarge and perpetuate their own advantages to the exclusion of possible competition. If this were allowed there would soon come a war of contentions. The telephone companies must and would seek to exclude the deadly electric light conductors from the spaces near their weaker lines as has already been done with the conductors overhead. There would be a struggle and contention for spaces, a perpetual digging side by side and in succession in the same streets, until the annoyance would raise a public clamor to sweep away the nuisances as with a whirlwind. To build a conduit merely for the use in common of existing companies would be equally and even more disastrous in the end, since the companies themselves could not agree about their diverse wires with each other; nor would it be possible to assign by legal authority a division of privileges and spaces between them. The result would be that the strongest would win the fight, control the conduits, laugh at expectant rivals, and dismiss from their calculations all fear of competition.

There is only one practical solution for this underground wire problem. The cities themselves in this country, as the governments in Europe, must own and control *the whole system*—both conduits and cables—constructed and arranged in harmony of service beneath the pavements; or, if such a course is not within their municipal powers or consistent with public policy, then the city authorities, where wires are to go underground, must control, absolutely and perpetually, the single company allowed to occupy the streets, so as to fix at all times in the public interest and fairness to all users, the rental for the wires; and more important still, to see that equal opportunities are secured for new companies who have the means and the will to establish a fair competition in the public interest and for the general welfare.

The President: We have listened with a great deal of pleasure, and I hope not without some profit, to the very interesting paper of Mr. Shelbourne, who, as we can all see, has given very careful attention to this subject; a subject which I think you will all agree with me in saying is by all odds the most intricate and difficult one which the electrical engineering profession has to deal with at the present time. It affords abundant opportunity for discussion and probably will continue to do so for some years to come. I see Mr. Lockwood among the members present this morning; he has paid a good deal of attention to this question in the course of his every-day duties, and I hope he may be able to favor us with a few remarks on the subject.

Mr. Lockwood: It is with much disappointment that I note the slenderness of the representation here to-day. I am quite sure that this room might have been full of members who could have listened with profit to such a paper. I am glad to say I have been instructed and interested, and perhaps I ought to say that some portions of the paper have even amused me. I say that in all deference to the ability of the author.

The paper of Mr. Shelbourne seems to refer more particularly to systems of wires which comprise all or a great number of the different utilizations of electricity. I am entirely in accord with his prefaratory remarks regarding the use, sometimes totally unauthorized use, of the word system. The word has been applied to a great number of inventions and plans and schemes which are characterized more by lack of system than by any other one feature. Perhaps the company with which I am officially connected has done as much as any one concern in North America upon the subject of underground conductors. We have not believed that the overhead wires are so much of a nuisance as people who have nothing else to do but to think of underground wires, believe. We think that wagons, carriages, and carts, and sometimes buildings, though useful are at the same time not ornamental, but we are very willing to tolerate them for a few years longer upon our streets because of their uses, and believe that the same considerations should guide us as we listen to the cry which has been made about the uses of overhead conductors and wires, about their unsightliness and about the trouble which they bring on roof owners and everything that is said against them. In talking about these things however, we sometimes lose sight of their utility, and of the fact that if they were not used and not useful they would not be tolerated for a moment; but we have also recognized that sooner or later the majority at least of the wires must be put out of sight, and we believe that ultimately the increased expense of burying the wires will be offset by the decreased expense of maintenance and by the comparative ease with which future discoveries will enable us to work them. In view of this, we obtained rights in Boston and ran a pair of conduits in two directions from the main central telephone office, at the corner of Pearl and Franklin, towards State, which is the Wall street of Boston, and another up Franklin street towards Washington street, and there are between 700 and 900 miles of wire now laid and operated as telephone conductors. The method we adopted was what is sometimes known as the Mackintosh system. It consists in establishing vaults or chambers underneath the surface of the earth, at street corners, and digging trenches from chamber to chamber and depositing iron tubes in those trenches, surrounding the tubes with concrete or other cement, and then drawing cables through the iron tubes. The size of a tube is three to four inches with gas thread joints. We lay the tubes first be tween each two chambers, and draw the cables in, and to be perfectly fair we adopted for trial all the good cables we could find, and we found that they all worked fairly well mechanically. As for insulation we found the chief trouble we had was at the joints in the chambers, and at the ends where the wires were separated. We brought the tubes right into the basement, and then carried them up by lead-covered cables to the operating room. We ran the same grade of cables up to the top of the building where we finally distributed the lines to the several points of destination. As I understand it, by the law which is at present in force in New York, *that* is prohibited, and the wires must stay underground from the point they start from, to the point they reach; and, after that, they must stay underground, because no wires are allowed to be above the surface of the earth, even in buildings. But we found they worked fairly well. Even in a half-mile line, however, of telephone wires underground, retardation, due, of course, to static induction is perceptible, though not to the subscriber. But when a subscriber comes to add on to the length of his line, say from the central part of Boston to Jamaica Plain, retardation is plainly perceptible indeed. The subscriber does not know what to lay it to, and we do not usually tell him. He generally lays it to a bad battery or to the transmitter, and he usually makes it the basis for an application for a rebate. There is another thing quite noticeable in this relation which I have seen referred to in the British text books with respect to the automatic system in vogue in England. Messages originating at the end of the underground section can be carried to the other end of the overhead line and will come up and be reproduced in articulate speech much easier and clearer than messages going the other way. Messages, for example, originating at State street will come out fairly clear at Jamaica Plain, but speech transmitted from Jamaica Plain comes out in a very muffled sluggish way in Boston. This is entirely as it should be. Although I am not particularly impressed with the result as being favorable to business I am glad to think that it corroborates theory, because when the electricity generated by the induction coil of the transmitter starts out from the underground end it is fresh. It has the hardest part of its work to do while it is fresh and consequently it does it well, and the overhead part of the line is comparatively easy on account of the distance from the earth and is traveled over with facility, whereas coming the other way the telephone current is slender. A little leaks off at every point of support, and when it arrives at the point where the hard work commences there is not much left to it. The consequence is that it nearly all is dissipated upon the surface of the conductor. In Pittsburgh, Mr. Shelbourne's paper to the contrary, notwithstanding, I think there is more telephone wire underground than in any city of the Union. There, wooden troughing is adopted, in which lead covered cables are laid. They are not more than a mile long, and a majority of them not more than half a mile. They are brought out on poles at the end of the underground stretches and distributed, and for some reason, retardation is not so perceptible in Pittsburg as in Boston. In Washington we have to put wires underground on account of the æsthetic tastes of Capt. Green. Capt. Green set out to find out what wires might be laid underground, and what wires not, and he interviewed certain electrical engineers, some of whom are in this room now, and in his investigations he found out that the British government had its wires in London in tubes under the sidewalks, and he did not care to investigate further, and consequently, from that evidence, jumped at the conclusion that as some wires are under ground for a certain length, all wires might be put under ground indefinitely, and he made his report accordingly; and it is now stated by legislative bodies especially, that there are no wires overhead in Washington. Any person who has been in Washington lately, would find it hard to believe that there are any wires underground, so many are overhead; likewise in Chicago.

I noticed that, in Mr. Shelbourne's paper, the statement is made that all electricians understand that metal envelopes connected to earth act as screens for induction. Now, for the last five years, I have disclaimed the title of electrician, because I do not like to be in the majority. There are a great many electricians, and while they may all understand that metal envelopes connected to earth act as screens, I, not being an electrician, do not altogether agree to that statement. It is true, if you have two conductors, and place a metal screen between them, and charge one of them statically, that metal, especially when connected to earth, does act as a screen. It is not actually true that metal envelopes around metal wires connected to earth, act entirely as screens. There is no doubt that the induced current between the two wires is checked, to some extent, by any metallic covering, because the way it acts is to develope a current in the intermediate conductor, *i. e.* the metallic envelope itself and by connecting to earth we extend that wire indefinitely; that is, you make the earth a part of the screen, and by so doing you disseminate the induced current over a large amount of surface, and thus the effect is carried away to a certain extent from the adjacent conductors. Incidentally, I may mention that the United States patent which covers that point, expired yesterday; so we may now cover all our wires with metallic screens, if we wish to, indefinitely.

Mr. Shelbourne: I referred entirely in my paper to dynamic induction. Such metal screens connected to earth increase static induction of course.

Mr. Lockwood: There was another point mentioned, based upon the statement in the report of the Brooklyn underground commission, which I thought myself was somewhat unaccountable —that the use of iron was detrimental to the flow of electricity in conductors—the use of iron in an envelope or screen. It has been found, and I think not very long ago, that different metals used as conducting envelopes had different results, and I have found, and my associates have found that while the results attained by the use of aluminum, bismuth, copper, brass, lead, tin, and many other substances, are all alike; and if you do not connect them to earth there is no great effect, yet if you inclose the insulated wires in iron, particularly very soft iron, there is a very pronounced effect in the diminution of dynamic induced currents from one wire to the other. The reason I think is that the force of the induced currents by virtue of the doctrine of the conservation of energy is transformed in that soft iron covering into a certain amount of magnetism and is thus prevented from exercising itself adversely in the formation of an induced current between wire and wire.

There was a further statement made as to the relative effect of induction between telephone wires in wet and dry weather. It is an undoubted fact that telephone wires, especially long ones, have worked much better in wet weather than in dry It is also a fact that telegraph wires, with bad joints in them, work better in wet weather than they do in dry, especially when the insulation is very good. In speaking of telephone wires we should remember that not only is the telephone such a sensitive instrument, not only is it subject to induction and to annoyances of all descriptions, due to the presence of other wires, to earth currents, to atmospheric currents, and to currents induced by crossing the magnetic meridian of the earth, but in addition to all this they are annoyed by adjacent telephone lines. We can hear other people speak who are not connected with the same wire that we are This is more particularly amplified in my own paper, and I think the better effect we get in rainy weather is owing to the following circumstance: that a great deal of the interference between wire and wire is due, not to induction, but to leakage along the cross-arms and through the covering, and from point of support to point of support, and this, of course, explains readily why the lines should work better and more quietly and should have less interference one with another during heavy rain storms when the supports and cross-arms and poles are covered with a surface of water; and it is not distilled water altogether, for it is pretty well charged with saline matters, and it makes a reasonably good conductor, and affords a means of escape for the induced currents and carries them away to earth at every pole, thus freeing the lines from interference with one another. A mere drizzle of rain makes a kind of a weather-cross; but, after all, the poles, so many of them, make a better conductor to earth than the different wires would.

With respect now to static and dynamic induction, I am something of a purist in terms, and it has often mortified me extremely to hear professors of electricity, I mean practical professors, not college professors, because they are as a rule correct—talk about the two interfering effects of electricity, namely induction and retardation, whereas retardation is nothing more nor less than the result of induction; and in the prosecution of my investigations and considerations, I have about come to the conclusion that static and dynamic induction are really but different phases of the same thing. If we send a charge into an insulated conductor a corresponding charge is induced in an adjacent conductor. If we send a current into a conductor an induced current is induced in an adjacent insulated conductor, and I have come to believe that therefore the difference is nothing more than this—that dynamic induction is induction brought about under circumstances where it has a chance to flow; whereas static induction is the same thing thrown upon a body where it has not a chance to flow, and consequently must stay there. That is, static induction is merely dynamic induction in a state of rest.

Now, with respect to the lead covering. Mr. Shelbourne's paper stated that many lead cables—I think I am using his own words—have been sold to telephone companies of the roughest exterior. It is rather hard on telephone companies, but I presume he referred especially to telephone companies which are not licensed by the Bell Telephone Company, those being the ones of the roughest exterior. As a matter of fact, there have been some very bad lead cables sold; but many bad lead cables have been made and they have to be sold. The lead is generally much better than the contents. I think they would sell better if they would adorn the lead a little more; because books sell better when they are bound well although there be nothing but trash inside. As a rule, now, telephone, and electric light, and telegraph companies are more particular about the article they order than they have ever been before. Everywhere I go, I find a new thing has come up and it has been talked of; I am very chary in telling them what I think of it, because I don't know myself—well, they say, "We think it is a pretty good thing, but we want some one else to try it first." Most of the lead-covered cables, however, which are now being manufactured, are of very fair character, having high specific insulation and pretty fairly low inductive capacity; because nearly every manufacturer has found it to his interest to adopt the best methods, to use the best materials at his disposal, and to pay good prices for skilled labor. They found they must do it to hold their own, and whether the insulating material be paraffine or rubber, or the material which in Pittsburg they call ozite, they all try to get the best effects out of it, because if they do not they won't sell much. They may sell a cable to an unsophisticated new manager, who is in his first position, but they won't do it again; because it does not take a manager long to find out that his position depends on the cheapness and expertness with which he can get through his work. It is a fact that a lead cable placed in the earth without protection is attacked by gases. I am very glad that I can concur generally in the remarks which were given in this paper, and I think, with regard to the gases that attack lead, that it is abundantly proved that ammoniacal and carbonic acid gases attack lead more severely than any others, and when they do attack it the effect is extreme. But it is also found, and this is based entirely upon experiment and upon experience—I see it mentioned in the Brooklyn Commissioners' report—that by alloying the lead with tin these results are avoided to some extent. That is true, and by alloying the lead with antimony the same results are avoided. The lead will then stand almost any gas Limey soils, I understand, are also very hard upon lead.

Now, I can hardly agree that it is judicious that one concern, whether it be a city government or a state government, or an organized corporation, should be allowed to monopolize the conduits of a city, and say to the telephone companies, "You may occupy *those* wires and use them," and, if you are a telegraph company, "You may take *these* wires and use them, and, if you are an electric light company, you may take *these* and use them." I think it would be very difficult, if there were troubles in one wire to convince the corporation running the wire that the trouble was in the wire. It would be in the sending instrument, or in the receiving instrument, or in the lamp or dynamo, anywhere but in the wire. A case of divided command is always productive of great trouble. If one commander wants to attack, the other one thinks it is best to make a three months' siege. Every case of divided command that ever I have seen has been productive of trouble and disturbance; not only that, but this corporation would take upon itself to say what kind of insulation should be used for one class of service and what kind for another. They would take it upon themselves to regulate the thickness of the insulation. Under those circumstances, it is no wonder that telephone companies, and electric light companies, and telegraph companies, and every other sort of company utilizing electricity, should want to use their own conductors. Which of us would care to commit our property to the control of a foreign concern of which we know nothing, and, for all we know, we might find ourselves renting these wires of a foreign and inimical corporation. It would be very easy for one corporation, desirous of owning the earth, as I have known corporations to be, to own a controlling interest in the concern. In such a case it would be easy for them to do, as the Pennsylvania Railroad Co. did to the Baltimore and Ohio, during the period when the latter company advertised to run its own Washington line via the New Jersey Central. They said: "Certainly, you can have all of our locomotives and cars that you want." But to reach the Philadelphia, Wilmington and Baltimore road at Philadelphia, the trains had to pass through the Pennsylvannia yard, and when we came to travel over that line we found that we were unavoidably delayed in the yard, at Philadelphia, three or four hours, and people found if they were going to Washington, or coming from Washington, they had better take the Pennsylvania trains, because *they* never had any trouble in the yards. *They* always got through on time. If I was running a company, if I was general manager of a concern, instead of being an humble official on a salary, I don't think I would want to trust my wires to any outside concern no matter how friendly they might be at the outset.

The President: The experiences and conclusions of a practical man, like our friend Mr. Lockwood, are always of very great value. He has been seeking, in the course of his investigations, for the best result, and perhaps he occupies as impartial a position towards the various inventions, and methods, and systems, as any one man who has occasion to investigate them. I think he has given us some additional testimony as to the difficulty of the problem which we are attempting to solve; certainly some of his conclusions are entirely new to me, and probably to many others who are present. I would be very glad to hear from any one else who has any remarks to make.

Mr. Mailloux: I have only one point to touch upon, which is called to my mind by my friend Mr. Lockwood's remarks, as to the analogy, if not the similarity, of cause and effect of dynamical and statical induction, and also, at the same time, to notice particularly the statement made in the paper by Mr. Shelbourne, about the influence of inductive capacity—static inductive capacity on the dynamic induction. Now, I believe the paper said that the dynamic induction is affected by the static inductive capacity, of the medium. Now, I do not believe that there is any experiment or any demonstration at all that would uphold that, but rather the contrary; and this leads me to say that I agree with Mr. Lockwood in the belief that electro static and electro dynamic induction are identical, when we consider them in their relation to the great law of the conservation of energy, in the relation that action is always equal to re-action; they both act and produce retardation by their re-action. There is one thing that Mr. Lockwood has not, I think, noticed; that electro-static induction is largely influenced by the electro-static condition of the surrounding medium, while electro-dynamic induction has no reference to the electro-static condition of the medium around it. We all know that electro-dynamic induction is a phenomenon which involves the action of magnetic lines of force, and that there could be no current produced if there is no conductivity; or, to put it in another way, that the amount of electrical current produced by electro-dynamic induction varies inversely as the resistance of the medium, without any regard whatever to its electro-static inductive capacity. We may consider electro-static inductive capacity as being itself a function of a certain resistance, but that resistance seems to be of a considerably different nature, involving a certain amount of molecular tension, which is probably, at a right angle. It is an action taking place in an entirely different direction from the one in which electro dynamic induction takes place. I have no doubt at all that the direction in which the lines of force are propagated axially, or the stress which is produced by lines of force in the medium is in exactly the same plane as the electro-static induction, whereas, we all know that the current itself is at right angles to that, and there is a certain relation brought out by Clerk-Maxwell and others, that bodies which are non-conductors we generally find to be of the highest electro-static inductive capacity; whereas those which are the best conductors are the poorest.

Mr. Maynard: I would like to ask two questions. What has been the experience as to the destruction of the lead covering of underground cables, and have there been any cases where fires have been caused by the current in electric light wires laid underground?

The President: Can any one present give us any information on those points?

Mr. Maynard: The first question is in regard to the lead covering of cables laid underground being injured by ammonia and carbonic acid. It is well known that those gases will destroy it, but what has been the experience, how long does it take?

Mr. Mailloux: I remember distinctly that at the first meeting we had here in this room there were exhibited on that shelf a large number of samples of lead pipe and there were labels on them the same as on these samples. The degree of oxidation was of course shown by sections of the pipe, and I saw pipes there that had been used for carrying water for something like forty years, and which were apparently not at all harmed, having evidently suffered only a very slight disintegration. It appears to me like a sub-oxide of lead, or perhaps a form of carbonate, which had formed in the interior of the pipe, and yet the process did not appear to have extended sufficiently deep to impair the utility of the pipe. If a pipe can stand usage for forty years in carrying water, it ought of course to be able to stand usage for a long time in carrying electricity, provided we get it in the same condition. I do not know very much about the corrosion of pipes by ammonia gases and carbonic acid gases, but I should imagine there might be something of that nature. Some years ago, in working storage batteries, I had occasion to go into the corrosion of lead deeply, and there was at that time a great deal of discussion going the rounds of the journals in regard to the formation of sulphate of lead in storage batteries. Perhaps you may not see the evident connection between sulphate of lead and carbonate of lead, but, as I understand the chemistry of it pretty well, I can see that there is a great connection between the two. For a long time we were troubled with sulphate of lead forming in the batteries. In a short time sulphate of lead would have eaten up the plates, and would have produced a form that would have ruined them, and it was a very troublesome thing to deal with. The battery became useless very quickly, and there was no means of remedying it, and it was not discovered until a long time after, as the result of some chemical reasoning, simply that the thing was produced by some acids contained in the solution used. Some advocated a stronger solution of acid, others a weaker solution. But the jist of it turned out to be this, that in the ordinary sulphuric acid of commerce there was a slight amount of nitric acid as an impurity. In the making of sulphuric acid they use nitric acid, which becomes converted into nitrous acid, and immediately takes another molecule of oxygen from the air and becomes nitric acid again, so you could go on indefinitely making nitric acid. Carbonic acid will not attack lead of itself. You may put a piece of lead in a solution of carbonic acid in water, or else put it in carbonic acid gas, and it will stay there an indefinite time without manifesting any change at all, but if there is some substance like nitric acid, which can oxidize lead and convert it into a nitrate, then almost any acid that happens to be lying about, and in this case carbonic acid, would be likely to attack it. So I don't doubt at all that the ammonia furnishes the nitric acid, in combination with the oxygen of the air, which produces the disintegration of the lead, and the carbonic acid takes hold, and forms a new combination, and leaves these other elements there to go on again for ever. So it appears to me if we put in a substance like antimony or tin, as Mr. Lockwood says, that it is not so likely to form stable compounds with nitric acid. I have no doubt at all that nitric acid is the thing we have to fight in the lead pipes. I think that if experiments are made with a view of tracing it to nitric acid, we will find out that that is the trouble, and, if we do find out that that is the trouble, we shall have made a step toward finding a remedy.

Mr. Lockwood: These remarks of Mr. Mailloux seem to me to accord very well with the text given us in Mr. Shelbourne's paper. He says, however, in respect to the pipes he saw in this room some time ago, that because they worked so well with water so many years, they ought to work well with electric wires. The doctrine of *ought* is very good, but it does not work in practice at all. We know there is another doctrine, namely, the depravity of in animate things, which comes in there. The fact is that the very deposit on the interior of lead pipes, caused by the water, acts as a preservative. As far as the outside of the pipe goes, it depends altogether on two things—first, the nature of the soil, and secondly, the nature of the attacking agent. Not very long ago the Western Union Telegraph Company seized upon a street in Boston called Friend street. It is not much wider than this room, and the side-walks take up one-half the street. They put up one of their enormous lines of poles there, with the cross-arms, and a great number of wires outside the windows, and the tenants made a great cry about it, as they ought to have done. The Western Union thought, as they put up their poles in the night, that possession was nine-tenths of the law, and that they would be able to keep them there. But the popular voice was successful. Property owners said they might go on the roofs if they wanted to, but they declined to do that, and went underground with their wires from State street through Friend street. Now, everybody who knows anything about Boston, knows that Friend street is lined with stables on both sides. These wires, of which samples were shown to me, were encased in lead, and it is not more than a year since they were laid down. The specimens they pulled up are very badly used up already. It must be owing to the refuse of the stables soaking the earth with these carbonic and ammoniacal gases which tend to form nitrates. These must be the "stable" products that Mr. Mailloux spoke of. (Laughter.)

MR. MAILLOUX: It strikes me that Mr. Lockwood had to lead his horse through a great many turns to get to the stable.

MR. SHELBOURNE: I am able to say in regard to this Brooklyn case that these cables, as I understand, were down some eighteen months. They were placed in the streets about the City Hall. The statement about them, which came from the Brooklyn Commissioners, was not correct. Of course they got their information from other persons, and perhaps were misinformed. I consulted Mr. Sargent about the conditions and facts of the case, and he gave me the exact particulars as he had learned them. This carbonate of lead appeared from these cables where they left the conduit, while being pulled out of it, and as Professor Plympton told me, this carbonate was picked up by the handful on the spot. I found, as against the theory of the water gas acting upon it, Mr. Sargent said that where the water gas escaped the most perceptibly, that is where the cables from the conduit entered the building of the Exchange, that there was no action upon them at all, showing that we must look for some other reason for the carbonate of lead than the action of carbonic oxide in the water gas. Now, if the carbonic oxide escapes from the pipes into the soil—it is well known that carbonic oxide is very light—it has about three-fifths the specific gravity of carbonic acid—carbonic acid of course being much heavier than air—it is apparent that the carbonic oxide, or monoxide, not being absorbable by water in the soil, on escaping from the pipes, would directly find its way out of the soil and rise in the air. The statement in regard to the wires in Friend street, confirms what the analytical chemist says in his memorandum. It is not that the carbonic acid acts by itself upon the lead, for it will not; but, as that memorandum maintains, the animal manures penetrating the soil and the decayed vegetable matters produce nitrate of ammonia. Then the action on the lead is not direct, but there goes on a series of actions and re-actions till the result is the carbonate of lead. There are two or three actions and re-actions which take place, and which are quite intricate in the ordinary production of white lead. The ammonia nitrate is the first thing that is produced from these soils. Nor is it competent to the direct oxidation of lead. Lead does not oxidize under such conditions. Lead nitrate is first formed and then the oxygen of the air brings in some of these intermediate actions and re-actions in connection with carbonic acid which result in the production of the carbonate of lead. Mr. Sargent exhibited to me a piece of cable that was brought out of the pipes, and while it was very evident that corrosion had taken place from the pitted condition of the surface of the lead; yet, from the amount of waste or disappearance of the lead, as I could judge, that corrosion might have gone on perhaps for eight or nine years before the lead would have entirely disappeared Another element enters into it. As the coat of carbonate of lead becomes thicker, it protects the metallic lead beneath it from further rapid progress of the corrosion.

In regard to the question about adulterating the lead with tin, etc., I was aware that the purer the lead the more readily it would be acted upon under such conditions. When I was a student in college, it was stated to the class in chemistry, by Professor Silliman, that rain water affects lead very readily, and the purer the water the more rapid the action; but, if you want to corrode rapidly a lead pipe, put it in a drain where it gets water impregnated with all the refuse of decaying vegetable matter; but as to the question of the cost of that tin adulterant, that is of some importance. If lead is taken at four cents a pound, suppose it requires three per cent. of tin, and metallic tin costs four or five times as much as lead; therefore, the cost of the tin would be a very considerable element. The tin, of course, was spoken of in the report of the Brooklyn Commissioners, and afterwards mentioned to me by Professor Plympton. I said that the cost of the tin required to enter into one hundred pounds of lead, would be something like sixty to sixty-five cents. I also mentioned to him the substitute Mr. Lockwood spoke of, antimony; and I also suggested, as a preventive of the corrosion of the lead covering of cables, the adulteration of the lead with metallic arsenic, which we can buy at five cents a pound. Now, that is as far as I think I am able to answer Mr. Maynard's question.

In regard to another point discussed by Mr. Mailloux and Mr. Lockwood, that is, the distinction between dynamic and static induction, of course, when induction results in currents which interfere with clear and distinct service in the telephone, we understand that is dynamic induction; but as to the fact of there being no conductor outside of the insulation as remarked by Mr. Lockwood, as to static induction, to receive or carry away the current, look at the conditions in the Atlantic cables. There, outside of the gutta percha, you have the whole ocean to carry it away. Again, it is shown by the experiments, I believe, first of Sir William Thompson, in regard to the early Atlantic cables, that retardation was the same, whether the battery used was ten or a hundred cells. They first tried, in the cable of 1866, to get over sluggish action of the electric current by increasing the size of the battery. I believe they used as many as a hundred to three hundred or more battery cells upon that cable, and also dynamo machines.

A **Member**: They used strong induction coils.

Mr. Shelbourne: Of course you have there the gutta percha core of the cable surrounded by the whole ocean. The armor and the jute put around the core of the cable do not, of course, prevent the salt water from getting right in next to the core, con-consequently you have there the favorable conditions of static induction. The conditions are exemplified by the Leyden jar. Now, if the induction is greater—static induction—there being no surrounding conductor to carry it away, why then you could get a charge into a Leyden jar greater, when there is no connection with the earth, than you could if there be such connection. It is found, however, and laid down in the books that in the Leyden jar, if you do not connect the outside tin foil with the earth, you can get but a very slight charge. If you do connect it with the earth, the action and re-action goes on till the greatest possible charge is obtained under the other conditions present. Therefore, it seems to me, that there must be a distinction taken between the conditions of the action and re-action of dynamic induction and of static induction.

As to the better effect of iron than other metals as a screen of induction connected with the insulation of the single wires, that was a point that I did not touch upon, and if Mr. Lockwood made his remarks, as based upon my paper, he misapprehended it. I very early became convinced that there was an additional effect to be produced by the use of iron as an immediate screen instead of any other material, but the difficulties in that case are so great mechanically as to make it impracticable. I took out, some years ago, a patent that was related to that subject, in which I claimed the use of the magnetic oxide of iron as an induction screen; but it is practically of no value, because under the conditions where it would be necessary to use it instead of the ordinary tin foil it would take up so much space, that for the benefit it would give, it was impracticable. My remarks as to the case were upon the use of iron as a conduit in which a large number of conductors or cables might be inclosed. Now, the statement is that such an iron conduit, in which lead covered cables are used, would cause retardation in the cables within it—I do not admit such a statement to be true, as we understand and speak of retardation being the result of static induction. In the beginning of the underground telephone business in Brooklyn, some persons who proposed to do some of the underground work —Mr. Sargent, as stated by Prof. Plympton to me,—wrote to Mr. Preece about the sort of conduits he would recommend; and Mr. Preece replied that these wooden boxes creosoted, he did not find advantageous, because he found that the coal tar or creosote would act upon the gutta percha insulation, and therefore, they didn't think of using them, and he concluded his letter by saying, "Why don't you take the ordinary iron pipe? That is a thing there will be no question about."

Mr. Lockwood: Would you put the entire pipe immediately in the trench or ditch in contact with the earth?

Mr. Shelbourne: Certainly. The iron in such a case, being in contact with the earth, can only act as a conductor away to the earth the same as any other metal would do. There are, however, probably dynamic reactions that would take place between the iron pipe and the conductors, due to magnetic variations produced in soft wrought iron pipes, by the make and break or rapid variations of the currents in the conductors.

Mr. Lockwood: I think you are quite right, but there is this to be considered—if the enclosing pipe, be it iron or any other metal, be in direct contact with the earth, it virtually surrounds the conductors with the earth, and, therefore, they are more exposed to the retarding influences of the static induction.

Mr. Shelbourne: That is, so far, true; but I also spoke of the wires that were in the individual cables inside of the conduits being in contact with the earth, that is, in grounded circuits. In such cases, when those wires are not in use, and other of the wires in the cable are in use, those not in use admit the access of the inductive nearness of the earth in the same manner, and, perhaps, in even a greater degree than the conduits. There was one further consideration in regard to that, and it is this—so far as dynamic induction currents are concerned, we will suppose that the earth is in a condition of dryness around these pipes. Then the result of dynamic induction, from the cables in the one to reach the cables in the other, if the iron pipes are alongside of each other, and not touching, would be that the conduit itself—the iron pipe itself—would take up the current of induction, and if the earth is dry between them the pipes would carry the currents to some point on the line where the earth is wet. But the iron pipe would not afford any more formidable conditions of static induction than any other conductor, wet earth for instance. Now, it is found by the Commercial Cable Company that they get a greater charge in the wires, in other words, the conditions of static induction are greater when there is water in the earth, sufficient to go through the armor of the cable and thoroughly wet the jute under the armor, and hug, as it were, the insulation of each of the conductors, and thus afford the better conditions of static induction between the outer surfaces of the insulation and the wires within the insulation.

The President: The Chair regrets to say that, owing to the lateness of the hour, it will be necessary to curtail this very interesting and instructive discussion. And if any other gentleman has further remarks to make, I hope he will be as brief as possible.

Prof. Young: I had charge of a lead pipe aqueduct in Hanover, in New Hampshire, that was laid in 1810. It runs through the village, and every now and then it comes up in people's barn-yards, and in the barn-yards where it comes up it lasts about five to six years. I had to replace some three or four of them in the twelve years I had charge of them. The pipe was inch and a-half pipe, and was perfectly good, except at some places where it crossed a road or went under barn yards.

Mr. Mailloux: It does not matter at all whether the earth touches the iron pipes or not. If a current passes through them is of a wavy nature, as it would be in telephone transmission, the current, as the wave rises or falls, would produce a change of magnetic condition in the conduit, and it is well known that the magnetic field around a conductor expands and contracts as the current rises and falls, and that each one of those expansions or contractions would tend to magnetize the conduit at that particular point where the wave happens to be in circumferential direction. Now, as this thing gets magnetized, it would exert a reaction on the impulse itself, and it doesn't matter whether it is one part of the conduit acted upon or two parts of the whole length.

The President: In closing this discussion, I might mention one little thing which I happen to have read, that throws a good deal of light on the great durability of lead underground under favorable conditions. Long ago the early French explorers of the western country, I suppose one hundred and seventy-five years at least—I do not recollect the date exactly—in taking possession of the land on behalf of the French government, were accustomed to bury at the intersection of the principal rivers a lead plate with an inscription engraved on it, stating that the territory was taken possession of in the name of the king of France, etc. It is only a very few years since one of these plates was dug up, at the junction of the Ohio river and one of its branches, somewhere below Pittsburg, and the plate was found in a very perfect state of preservation. It was corroded but little and the inscription was perfectly legible, which, I think, is very strong evidence of the great durability even of the surface of a leaden body under favorable conditions.

The Secretary: Before the discussion closes, I would say, in reply to the inquiry of Mr. Maynard, as to whether fires had originated from arc lighting wires underground, that I have kept pretty close track of that branch of the subject, being on a committee of the Electric Light Association, and no case of that kind has come to my knowledge. But this may arise from the fact that there is but a very limited number of arc lighting wires under ground at the present time. The wires in Chicago are confined to isolated plants. There is no central system of street lighting as in this city; and with the exception of the wires in Chicago and those with which he is familiar in Washington, I believe there is nothing else in the way of underground arc lighting wires, excepting a system which has recently been established in Detroit by the Thompson–Houston, and that has been in operation only a short time, and therefore I have no information regarding it.

Capt. Michaelis: I would like just to say a word, in confirmation of the Chairman's remarks in regard to what I might call the chemical refractoriness of lead. The Government had stored all over the country thousands and thousands of pigs of lead under all conditions, some of it in cellars. I have seen some in Fort Carroll, where it was exposed to spray, and I never saw a pig of lead that appeared to have degenerated in any manner whatever. Yet, not long ago, I had occasion to examine about twenty tons of English bullets that had been stored in a dry place, and they presented every sign of degeneration. They were incrusted with carbonate, and I have been led to think that this apparently inexplicable degeneration of metal is due to galvanic action, and where the lead is pure, and we used to get pure lead years ago, that this action is not so apt to take place as it is with bullets, which we know contain not only oxide of lead, but other metals, zinc, tin, etc., and there you have a favorable condition for galvanic action; and I have no doubt, where there has been marked degeneration of lead pipe, that it may be due to the impurity of the lead and the consequent galvanic action.

The President: We will now listen to a paper by Prof. William A. Anthony, of Cornell University, on the great tangent galvanometer which he has recently constructed there, which in the absence of that gentleman will be read by the Secretary.

THE GREAT TANGENT GALVANOMETER OF THE CORNELL UNIVERSITY.

BY PROFESSOR WM. A. ANTHONY.

THE "mammoth tangent galvanometer" which was described in the *Electrician and Electrical Engineer*, of October, 1885, has now been in use for nearly a year, and it may be of interest to the Institute to hear a brief account of its working. It will be remembered that the instrument was constructed primarily for the direct measurement of large currents, and its large dimensions were necessary to adapt it to that purpose. At the same time it is possible to measure by means of it, currents as small as 1-100th ampére. The instrument is fully described in the *Electrician and Electrical Engineer*, but a description is given here in order that the various uses to which it has been put may be better understood. The needle is made of a number of thin wires, is hung in a copper block, and is very nearly dead-beat. The apparatus for observing deflections, gives these accurately to 20 seconds. The coils for heavy currents each consist of a single turn of copper rod 1.9 cm. diameter. There are four coils, two of them 200 cm. and two 160 cm. diameter. These are placed parallel to each other, the two coils of a pair being at a distance apart equal to their radii. As the coils can be used in series, in pairs, singly, or differentially, it will be seen that the galvanometer may be equally sensitive to widely different currents. In fact, currents of any value from 4 to 250 ampéres, can be measured by deflections of the needle never less than 25 nor more than 60 degrees. Four coils of 18 turns each of small wire, serve to measure smaller currents. The instrument has been used for measuring currents of dynamos under test, for measuring currents, for standardizing other instruments, and for a great variety of experimental work.

Its indications have been compared with those of the copper voltameter, with generally a very close agreement. The disagreements that have been observed, have been traced to irregularity in the action of the voltameter. It has also been compared with a calorimeter with very satisfactory results. All the observations that have been made with it, go to show that its indications may be implicitly relied on. In fact, those who have used it, have come to feel the same confidence in the results obtained, as when weighing a body on a good balance. In the use of the instrument, readings can be taken very rapidly, ten minutes sufficing for twenty readings which are ordinarily taken as a set in measuring currents, and the computation of results is extremely simple. There are no temperature corrections except where the highest degree of refinement is aimed at. The only correction that need to be considered in any ordinary case, is that due to variations in the horizontal intensity of the earth's magnetism, and the instrument contains within itself the means of determining the horizontal intensity at any time.

The advantages of the galvanometer over other methods of measuring large currents, will appear by considering the sources of error or uncertainty involved. Currents may be measured by shunting a smaller tangent galvanometer. Here the errors depending on the instrument itself are the same as for the larger instrument, but larger in proportion, since the dimensions of the smaller instrument cannot be measured with the same percentage of accuracy as of the larger. But in addition to these, there is the uncertainty in regard to the shunt ratio, which depends upon temperatures very difficult to determine accurately. With copper conductors, a change in the ratio of one per cent. would result from a difference of temperature of a very few degrees.

Theoretically, the best way to measure currents would be by reference to their own mutual action. That is, by means of some form of the electro-dynamometer. But any such instrument, when constructed for measuring large currents, involves large sources of error. The instrument must be of large dimensions, otherwise the cross section of the conductors will be large in proportion to the distances between them, a condition which makes it impossible to determine the constant of the instrument with certainty. The forces to be measured are very small, and any arrangement for carrying the current to and from the movable coil, must seriously interfere with its freedom of motion, and so impair the sensitiveness of the instrument. The writer of this paper had planned to construct a dynamometer in which a movable coil should be suspended from the arm of a balance, and the force exerted between it and the fixed coil, *weighed*, but no method could be devised for reaching the suspended coil with a current of 20 ampères even, without a loss of sensitiveness that was fatal.

Currents may be measured by determining the deposit of copper or silver. In theory this is very simple, but in practice, constant results can be obtained only by observing many precautions, and even with the greatest care, results will sometimes differ by one or two per cent. from the truth, without apparent cause. Moreover, these voltameter methods are not generally available, as they require too much time, and give only a time integral of the current, and not its value at any given instant. They are only of value for the calibration of instruments whose constants cannot be determined from their own dimensions, such as the various forms of ammeters, including the so-called "Vienna method." The indications of all such instruments are uncertain, unless they are frequently calibrated. If permanent magnets are used to produce a magnetic field, they are liable to a continuous change, and they always change in strength with change of temperature. If any of the forms of mirror galvanometer are used, as in the "Vienna method," the slightest change in the position of the needle with reference to the small coil, such as might occur from a stretching of the fibre, will change the constant.

To sum up: The tangent galvanometer is a very sensitive instrument, and its constant depends only upon its dimensions and the horizontal intensity of the earth's magnetism. Temperature affects the constant only as it affects the dimensions of the instrument. For the shunted galvanometer the constant depends upon the same elements, with the addition of a very uncertain shunt ratio.

The voltameter is usually inadmissable for direct measurements of currents; and the method requires extreme care to avoid errors in determining the deposit, which errors may arise from some of the solution being occluded in the deposited metal, or from loss of the metal while washing, or from other causes, difficult sometimes to assign. Moreover, this method is not an *absolute* method. Electrodynamometers, when constructed for use with large currents, lack sensitiveness.

Of course, the large tangent galvanometer is not a portable instrument. Few instruments of precision for absolute measurements are. It must be mounted in a place free from local magnetic disturbances. But it is the conviction of the writer, after extended experience, that, for purposes of accurate testing, or for standardizing other instruments, there is no other method for measuring currents, so reliable, so accurate, and so expeditious.

PHYSICAL LABORATORY OF THE CORNELL
UNIVERSITY, *May* 15*th*, 1886.

The President: The measurement of heavy electric currents, such as are used for lighting and power, is almost a new subject, and perhaps the first work that has been done in that line approximating strict accuracy is that which has been accomplished by means of Prof. Anthony's galvanometer, which he has spoken of in this paper. If there are any present who wish to make any remarks they have an opportunity.

Mr. Lain: As I had the privilege of being in attendance at Cornell the year in which this instrument was built, though it was also my misfortune to be obliged to leave the University, since I graduated last June, just before the instrument was in successful working,—in Prof. Anthony's absence I may be able to say something about it. A description of the instrument has, perhaps, been read by most of those present, but the way in which Prof. Anthony removes the errors of construction and errors liable to arise from surrounding influences certainly deserves some mention. In the first place, he received a large appropriation for the instrument and its appurtenances, and a house was especially built for this one instrument, a small frame house, in the construction of which not a particle of magnetic metal was allowed. The nails used were all of copper, the hinges were of brass. A copper stove was built especially for it and a copper stove pipe, and the gas pipes leading to it were of lead instead of iron, and then, as will be seen by the description in the *Electrician and Electrical Engineer*, the mechanical construction of the instrument is such that the errors of construction are removed almost entirely. Then Prof. Anthony speaks of the errors in the use of the copper voltameter. I chose that subject for a thesis last June, and was very much surprised at the obstacles I met in working it. I started out with something like twenty-four cells in series, and whenever one cell was stopped of course they would all be stopped, and the current started on one of them would also pass through each one of the others; and I found by taking the greatest possible pains that the discrepancies in the increase of the deposits on the negative plates were much larger than I anticipated. These arise from a variety of causes. In the first place, there is the addition of the salt of the liquid—the sulphate of copper—to the plate, which is accidental, and therefore irregular, that is, it appears that the liquid is built in with the deposit. Well, whatever liquid is built in in that way adds to the weight, and therefore makes an error in the computation. First, I thought it sufficient to simply allow the plates to be nominally dried before weighing them, but, after experimenting for a long while, I found that I obtained quite different results, if the plates were desiccated before weighing; so that the conclusions I arrived at in my thesis were that unless there was some arrangement—some acidity of solution, such that the amount of the metal removed by the chemical corrosion was exactly equal to the added weight due to this imprisoned salt—unless this should be arrived at, the voltameter would show results that were not accurate.

Mr. Mailloux: I would like to add in confirmation of the gentleman's experience, that for the last year I have been devoting my time almost entirely to working copper, and one of the first things I found was that there was almost an impossibility of making a relation between the amount of copper deposited and the amount of current passing. The books state that one ampere of current passed through for 386.4 hours will deposit a pound of copper, but I confess I have never made practice come to theory or agree with it. I was working for industrial purposes, one of which was electrotyping, and I have come to the conclusion that a great many of the determinations that have been made by means of the voltameter, using copper, and even silver must have been erroneous, and as the gentleman says there are some obscure causes involved, one of which he has brought to notice and another one which I think has not been mentioned before, and which is the occlusion of hydrogen by the metal itself. I had found that out practically by experiments. If a solution is not of the right constitution, instead of depositing copper you are depositing copper and hydrogen, and when you come to weigh the copper you weigh only the copper; you have no means of estimating the amount of hydrogen that is occluded there. As a matter of fact, you would never know there was hydrogen there. It took me a long time to surmise that hydrogen was there. It is said you get evidence of hydrogen when the copper is granulous—black. I have found hydrogen when the copper was perfectly regular, perfectly good and clear. I have deposited two pieces of copper and at the end of a week one would be perfectly rotten and the other as hard and tough as hammered copper, and that, I think, is one of the sources of error which make the copper voltameter utterly unreliable. I think that some form of tangent galvanometer, which gives the thing an absolute measurement taking the earth's component of magnetism as the starting point, is probably the most satisfactory thing you can get.

The President: I have observed for a long time that the confidence of experimenters in the results obtained with the voltameters were apt to be in the inverse ratio to the amount of their experience with it. Mr. Edward Weston, who I am very sorry not to see here to-day, has done a great deal of practical work in electrolysis and electroplating for many years, but has never been able to get any results which he had any particular confidence in, and his confidence has diminished the longer he has gone on. I have talked with him about it a good many times. I very much regret he is not here to give us the benefit of his experience, but it accords very closely with that of the two gentlemen who have last spoken, and of others that I might mention, and I think we might consider that it is pretty well established that it is not safe to place any very great confidence in the results obtained by the voltameter unless checked by independent sources.

Prof. Young: I was going to say there was one peculiar experience of Prof. Anthony which he does not speak of in this paper, namely, that the stiffness of the suspended wire is all the time increasing and the time of the vibration of the needle is increasing. I wonder whether others have come upon that same thing. I have found that the springs of our clocks at our observatory at Princeton are growing stiffer. Our mean time clock has certainly in that way increased its rate as much as some few seconds a day, in the last few years, I suppose from the increased hardening of the springs. Prof. Anthony finds it necessary in his galvanometer to check this co-efficient of torsion.

The President: That is a very interesting observation of Prof. Anthony's and should be borne in mind.

The Secretary: It has occurred to me that as one of the blessings which we were to derive from incandescent electric lighting was the reliability of the electric meter, which I believe is based on this principle of depositing copper, it would be quite interesting to know if the error alluded to would be in favor of the consumer or the producer of the electric light.

Mr. Lockwood: I would say, Mr. President, that is a question that will always answer itself, the same as the gas meter does.

The President: I believe that the actual method adopted and practised is a zinc voltameter. It has been stated in accounts which have been published of the central station lighting systems of this country in which this method of measurement is used, that the results are accurate within one per cent. I think there can hardly be any doubt that this is somewhat of an exaggeration, because I fancy it would be difficult to get that result in a laboratory every trial with all the time required to make the measurements. But it is very probable, I should think, that the results might be depended upon within four or five per cent. I should be very glad if any one present could give any information on that point. It is a matter of a good deal of practical interest. If there are no further remarks to be made on this paper, I would say that a little collation has been provided, and we will now take a recess of an hour to discuss that, after which we will listen to a paper by Mr. Thomas D. Lockwood, of the American Bell Telephone Company, on "Some Recent Advances in Telephony."

A recess was then taken.

The afternoon session convened at 2.15 o'clock, when Mr. Lockwood read his paper.

SOME RECENT ADVANCES IN TELEPHONY.

BY THOMAS D. LOCKWOOD.

Ten years ago a meeting of the American Academy of Arts and Sciences was held in Boston, at which Alexander Graham Bell expounded his ideas upon the electric speaking telephone.

Prior to that date, a patent had been issued to the same gentleman upon the same subject; a patent which many persons state they have since ascertained refers in no way whatever to the speaking telephone; a statement which many other persons, perhaps equally well informed, believe to be based upon a wish that such were the case.

The first line built between two distant points expressly for telephonic transmission, was completed April 4, 1877, and extended from the office of the electrical manufacturer, Mr. Chas. Williams, Jr., 109 Court St., Boston, to his house in Somerville, a distance of about three miles.

May 1st, 1877, the first lease of telephones for private line service was effected; and in May, 1877, telephones were first operated upon the exchange plan, through a switch board in the office of Mr. E. T. Holmes, 342 Washington St., Boston; the sub-stations comprising a number of different offices connected with the Holmes burglar alarm system by wires converging to Mr. Holmes's office. For a number of years it was assumed that the exclusive field of usefulness for the telephone, like that of the average and proverbial specimen of charity, not only begun, but also ended at home; that the local short line, or exchange service, was the only kind in which telephones could, or would be practically used. Recent experience proves this assumption as hardly correct. The exchange, or central office service, it is true is the more immediately practical and obvious utilization, and it was natural that the American people should measurably fill that sphere of action before looking for others, inasmuch as that was the line of operation promising the most speedy pecuniary return for the outlay. Lines of from a few yards, to a dozen miles in length have, however, been connected with exchanges, and these have in turn been supplemented as occasion served, by what are technically termed extra territorial lines; that is lines connecting different exchange centres; and from 1879 to the present time it has been a regular practice to talk over such lines with comparative ease, perhaps for an average distance of 40 to 50 miles. In some of the western states it has been a common thing to converse by telephone over much greater distances, by switching lines together, but not always with ease.

I think it well understood now that three conditions have conspired to retard what is at present termed long distance telephony. These are:

(*a.*) The uncertainty of obtaining satisfactory and speedy reciprocal communication, and the consequent slowness of transmission together with the inevitable result of such uncertainty, namely, the low prospective maximum capacity of remunerative transmission.

(*b.*) The extreme noisiness of long lines, and increased telephonic induction, or cross talk, which in many cases renders the single or earth terminal circuit insufficient.

(*c.*) The lack of transmitting instruments sufficiently powerful and trustworthy to develop voice currents capable of overriding the undesired currents and the noises produced thereby, and of sufficient E. M. F. and volume to affect the distant receiver with clearness and strength.

If it be asked at the present time "what is long-line telephony?" I answer—"Telephonic communication over lines more than 50, and less than 500 miles long." Six years ago I should have limited it to lines between 20 and 50 miles long; and six years hereafter I may possibly fix the limits of long-line telephony between 250 and 1,500 miles. The term is purely comparative.

The most noteworthy advance of the telephone in the past few years has been in the direction of increasing the distance over which communication can be transmitted satisfactorily, and the advance which has been made is, I think, undoubtedly attributable to the introduction of copper line wire, and to the radical improvement of the transmitting telephone.

It must not be supposed that telephone communication over long lines was until recently entirely unknown, even when we accept the above definition of a long line.

On the contrary, it is a well authenticated fact that in the earliest days of the speaking telephone, time and space were well nigh obliterated.

In the remote period when the magneto speaking-telephone was the only known—and was itself a new and wonderful thing—it was operated over lines of (for that time) really considerable length. On August 11th, 1876, for example, conversation was carried on at Brantford, Canada, over five miles off, between Brantford and Mount Pleasant, and on the succeeding day the length of line was increased to ten miles.

As early as November 10th, 1876, a very long line was successfully used. I find among the early records of telephony the following statement: "November 10, 1876. "We carried on a long "conversation on the lines of the Eastern railroad, using part of "the time a circuit from Boston to Salem, 15 miles; and part "of the time a circuit from Boston to North Conway and back to "Salem, and from Boston to Portland and back, about 200 miles "of actual wire."

This statement is made by Mr. Watson, (who like De Santy, was long supposed to be a suppositious character, being always at the other end of the line) and is noticed in the Boston *Post*, *Globe*, *Advertiser* and *Herald* of November 27, 1876.

In the early spring of 1877, with a box and magneto telephone, Mr. Bell in New York, conversed with his associate in Boston on a Sunday, and he speaks of the occasion in the following words:

"The longest length of real telephone line through which I "have attempted to converse has been about 250 miles."

"On this occasion no difficulty was experienced so long as "parallel lines were not in operation. Sunday was chosen as "the day on which it was probable other circuits would be at "rest. Conversation was carried on between myself in New "York, and Mr. Thos. A. Watson in Boston, until the opening "of business upon the other wires. When this happened the vocal "sounds were very much diminished but still audible."

"It seemed indeed like talking in a storm. Conversation, "though possible, could be carried on with difficulty."

There are in fact a number of such isolated cases and I have thought proper to refer to these as showing that the idea at least is old, and that the magneto telephone is not an utterly incapable instrument, even viewed as a transmitter. There is, however, a wide gulf between an occasional successful experiment, made under favorable conditions in which experts can understand one another, and regular every day successful commercial communication.

If by recent developments this gulf has not been permanently and solidly bridged, there has at least been a convenient and useful ferry established.

Before leaving the early years of the telephone, it may amuse, if it does not instruct, to refer to an item which appeared in the *Scientific American*, on November 29, 1879, entitled "How far can we hear with the Telephone?"

"This is a question frequently asked, but one which we believe "has not yet been definitely settled. The longest distance that "we have seen mentioned, is given in the item below, namely, "two thousand miles. But perhaps Mr. Edison has had more "extended experiences. If so, we should be glad if he would "let our readers know. An exchange states that Mr. Robert A. "Packer, superintendent of the Pennsylvania railroad, is at pre- "sent hunting with a party of gentlemen in Nebraska. A few "days ago he for two hours conversed pleasantly with his wife "and friends at Sayre, Pa., his brother at Mauch Chunk, Pa., and "his friends along the line. The medium was the railroad and "Western Union Telegraph wires, and Edison's telephone. At "the office in Bethlehem, Pa., connection was made with the "Easton and Amboy wire, and at Perth Amboy with a Western "Union wire and thence to Chicago and North Bend, Nebraska, "where the party are. The distance was about two thousand "miles and every whisper was audible."

Now if there is anything in the world that annoys one, it is to hear an apparently trustworthy account of something being done in one's own special line of work which, with every appliance for the purpose, with experience and special education, we cannot do ourselves. It is not therefore speaking too strongly when I say that this statement both mystified and exasperated me, for I knew certainly that at that time I could not accomplish such a feat; but I possessed my soul in such patience as I could make available and awaited developments; having at least a suspicion that there might be an error in fact, seeing that the veracious chronicler had already committed himself to the statement that Mr. Packer's business relations were with the Pennsylvania railroad instead of the New York and Pennsylvania Canal & R. R. Co., as it should have been. I had not long to wait however. In the issue of December 27, 1879, a second item appeared entitled "Long-Range Telephoning" (I think the original one should have been called "Long-Range Reporting,") which read as follows:

"In a recent issue of this paper an exchange was credited

" with the statement that Mr. Robert Packer, while traveling in " Nebraska, had conversed with his wife and friends at his home " in Sayre, Pa., two thousand miles distant, by means of a telephone. We now learn on good authority, that though Mr. " Packer's friends received his communication by telephone it " was not so sent by Mr. Packer. The message was sent from " Nebraska to Mauch Chunk, Pa., by telegraph; thence it was " telegraphed to the Sayre office of the Pennsylvania Canal Rail- " road Co. (of which Mr. Packer is superintendent), and from " there it was transmitted to Mr. Packer's house by telephone, " falling short of the newspaper report of the telephone's per- " formance by some nineteen hundred and ninety-nine miles and " a fraction."

Such is a sample of the long-range telephony of 1879.

When in the summer of 1879 a telephone line of two wires was built between Boston and Lowell it was regarded as a great achievement; for it worked well. It, however, epened our eyes to the phenomenon of induction in another phase to that in which it had heretofore been made manifest.

That phase in fact which in more recent times has been named "cross-talk." We found that when conversation was transmitted upon either wire, it would be heard equally well upon the other at the receiving station, and until many other lines were built, it was found practically impossible to operate both lines at once.

This was the beginning of lines to connect distant telephone exchanges and the seed from which sprouted the long-line telephony of to-day. When, however, the value of copper as a material for line wire was recognized, the commercial feasibility of long-line telephony, as above defined, became a subject of serious consideration, and exchanges located 75, 100 and 150 miles apart, were brought into conversational proximity.

The possibilities of the telephone were never brought before my mind in so striking a manner as when I stood in a little room on Broadway in this city, and talked with a fellow mortal in Cleveland, Ohio. Many of the members of this Institute will, doubtless, remember that when the compound wire of the Postal Telegraph Co. was built, and communication over it completed in 1883, first to Cleveland, and later to Chicago, a noble army of telephonic patentees hastened to try their patented telephonic receivers and transmitters over it, and how each and all, after successfully exchanging words with the western cities, went forth proclaiming to the world the unparalleled excellence of their special form of telephone.

When I first heard these statements I was firmly convinced that the achievements described, were due not to any special excellence of the instruments employed, but to the greatly superior conductivity and insulation of the Postal wire over any other that had heretofore existed, and my conviction was intensified after I had had an opportunity to make the test myself and had found that, not only could we make a Blake transmitter transmit speech which was perfectly reproduced at the receiving station, but that identical results could likewise be achieved with the magneto Bell telephone commonly used as a receiver.

To Mr. Thomas B. Doolittle, of Bridgeport, is due the credit of having first discerned the merits of copper as a material for telephone lines. A line of hard-drawn copper was erected by that gentleman in November, 1877, in Ansonia, Connecticut, a section of which was taken down in August, 1884, and found to be, when compared with any iron wire of like age, in an excellent condition. I may also say that from the first moment of my acquaintance with Mr. Doolittle, I have found him a strong and persevering advocate of copper wire for telephone lines, and, considering our present views upon the relative merits of iron and copper, it is fair to say that I think he has made out his case and was considerably ahead of the times. My own fear was that it would prove too soft for common use, would not stand up, would expand under increase of temperature and would fail to duly contract upon the resumption of normal temperatures. I had no doubts of its electrical merits.

The Postal wire, however, was electrically so far ahead of all expectation, telephonically considered, that it seemed to prove once for all that copper, if mechanically available, was decidedly the proper material to use, and it seemed also evident that if it would stand up alone it would be even more successful as a conductor, if the steel core were dispensed with.

Hard drawn copper wire was tried after being submitted to the various electrical and mechanical tests, and was not found wanting. In fact, it promised well, and the result was the erection of an experimental line of two wires between New York and Boston, which worked satisfactorily, and with sufficient reliability to encourage its proprietors to build a line of a number of copper wires between New York and Philadelphia.

The experience gained in building, testing and operating the Boston line has been utilized in the more recent one, which is a model line in many respects.

When we begun to use copper for this purpose, it was not easy to account for the comparative ease with which a line built of that material could be operated. It was attributed by many solely to the low specific resistance of copper, and I recollect instances where I have commented upon this remarkable point and have been met with the remark, "Oh, it is only a question of resistance." But it was obvious that there was some more deep seated reason than the low specific resistance; for, if we take two lines of equal resistance, one built of copper and the other of iron, the copper is invariably by far the easiest one to work.

This was, I confess, for a long time a problem to me, but has recently been wonderfully cleared up, by the masterly researches of Professor David E. Hughes, as detailed in his inaugural address, lately delivered before the Society of Telegraph Engineers and Electricians; with which every electrician interested in the communication of intelligence should familiarize himself.

His experiments showed that the E. M. F. of the extra current, in a solid iron wire is much greater than in a similar copper wire; that ordinary iron wire has, with rapid currents, more than three times the resistance during actual work than that supposed to be its resistance (although with standard iron and ordinary copper such is not the case), and that the extra current in wires furnished with a parallel return wire is much reduced, but much more in copper than in iron. Iron 15 per cent. and in copper 80 per cent.

It is also interesting to learn that the E. M. F. of the extra current in brass wire, compared with copper, is but as 13 to 20. This point may prove useful when a wire, stronger than copper, but of equal size, is at any time required.

These researches are so interesting and valuable that they gratify me nearly as much as though I myself had made them. I am aware that the statements of Prof. Hughes have been severely criticised by Prof. Weber and others, as was to be expected, but I am persuaded that his results will, in the main, be ultimately approved, and his views acquiesced in by the world of science; although it is very probable that some errors of detail may be found in them.

Approaching now advances made in instruments, I may say that it is noteworthy that nearly every improvement has been made in the transmitter. There are two good reasons for this. The first being that the receiving telephone came into existence well nigh as sensitive and perfect an instrument as it was possible to make it; and the second, that in view of the noises, made apparent in the receiver on long lines, due to undesired currents, it was manifest that the transmitting power it was that required intensifying, to the end that it might be able to develop currents of sufficient strength to override the disturbing currents, and that if a transmitter of sufficient power could be made, it was even possible to reduce the sensitiveness of the receiver, and thus weaken the disturbing noises by thickening the diaphragm, or by removing it to a greater distance from the magnet. The form of transmitter which has been found most successful is one in which granulated carbon in a loose and free state is employed as the current regulator. When first introduced it consisted simply of a handle, having a disc-shaped cavity cut in its face, the bottom of the cavity being faced with some suitable metal or alloy as copper, silver or brass.

The front of the chamber was closed by a piece of platinum foil, which served as a vibrating diaphragm, and the sides of the chamber were formed of the same non-conducting material as the body of the handle itself. The space between the back and front plates was partly filled with the carbon granulations, and the front plate protected by a mouth-piece. The instrument was then complete, and, though exceedingly simple in construction, worked, and worked well. When in use it was most efficient when held so that the diaphragm presented an angle of about 45 degrees from the vertical position, the upper edge being inclined backwards.

When this instrument was good, it was "very, very good," and like the little girl of the nursery rhyme, when it was bad, it was "horrid."

It had one grave fault, the granulating powder would occasionally pack itself into a mass, and was then anything but as sensitive as it should be; under such circumstances it became a very poor transmitter. The customary remedy for this disease may be indicated by the familiar words of counsel, invariably found upon the apothecaries label, "When taken, to be well shaken," and, when shaken, the sick transmitter would usually resume its duties. But an ounce of prophylactic is better than a pound of medicine, and the want was decidedly a transmitter equal to the Hunnings, but which would not pack.

The first step was the adoption of a horizontally mounted diaphragm, the speaking tube of which ended opposite to the lower face, and it was found that when the carbon granules were placed on the upper surface of this plate, the voice vibrations acted upon them with great force, and tended to loosen them if packing had begun. This was not; however, completely satisfactory. It was subsequently ascertained that the back plate should, to obtain the best results, be buried in the mass of carbon which lay on the diaphragm, or should dip into the same in the form of a pendant, and that the resistance of the entire instrument should be reduced as much as possible.

The most noteworthy, embodiment of these principles (or more properly speaking of the first of them) employs for the complementary or back electrode, a metal sieve, which is buried in a mass of granular carbon. In another form the back electrode takes a form something like that of a shade roller pulley, and has a number of holes bored through it in different directions, so that the carbon granulations can freely circulate. In both cases it is found advantageous to plate the electrode with some unoxidizable metal—such as gold; and to form the diaphragm as in the original Hunnings instrument of platinum foil.

One of the circuit wires is united to the diaphragm, the other to the back electrode, and the mass of granulated carbon lies upon the former with the whole or a portion of the latter immersed, or buried in it. These transmitters give admirable results. The tone, volume of sound, and clearness of articulation developed by them is most encouraging, and by their use the range of long-distance telephony has already greatly expanded even on long, single iron wires. The distance that they can be efficiently operated has not even yet been authoritatively ascertained, but, judging from the fact that instruments of the most inferior character can be made to maintain successful conversation between New York and Chicago over a compound wire, we are encouraged to believe that conversation can be easily transmitted over much greater distances than that by availing ourselves of the most improved forms of Hunnings's telephone. It is well known that long telephone lines are greatly troubled by the noises manifested in the receiver; these noises being due to magnetic or current induction, leakage from other wires, atmospheric and earth currents, and magneto-electric currents induced in them when they are blown about, and thus made to move across the magnetic lines of force of the earth.

It has been found necessary in order to reduce these disturbances to a minimum to adopt an old laboratory expedient, and to provide each line with a wire return as nearly as practicable equidistant with the direct wire from all known sources of disturbance, so that the disturbing currents, proceeding in the same direction on both sides of the circuit, will neutralize one another. But when we take such a double wire we find that it is not easy to preserve its benefits, and at the same time to connect it with a short exchange line at both ends, for, if we take a parallel wire metallic circuit trunk line and connect it with a short subscriber's single wire line by absolute contact, as in drawing A, it is obvious that we have lost the basis of neutralization, and only gained a conductor of lower resistance.

There are two plans from which we may choose. We may run a double wire to each subscriber wishing to use the long line facilities—as in drawing B—in which case the problem is at once solved; for, when we unite the two terminals of the subscriber's short loop line with the two wires of the long trunk line, we have simply extended the said trunk line half a mile or a mile, or whatever distance it may be further.

This plan, however, presents some disadvantages, in that it necessitates a double wire for each subscriber's line, and the concomitant changes in apparatus at the central station; and it is, after all, rather an inordinate expense to incur, when the subscriber may possibly only use the long line once a month.

The alternative plan is to employ repeating translating coils. These are really induction coils of peculiar construction, the two circuits of which are made much nearer each other in the size of wire and resistance than is usual in the ordinary coil.

One of these circuits—that which is composed of the finest wire, and which is wound to the highest resistance—is connected in circuit with the two ends of the long metallic circuit trunk line, while the remaining coil has one terminal, united to the single central station end of the subscriber's line, and the other attached to a ground wire. This arrangement is shown in drawing C, in which one terminal of the local side of the coil is represented as being united with a button switch, by which it may be connected with any desired subscriber's line. The beneficial re-

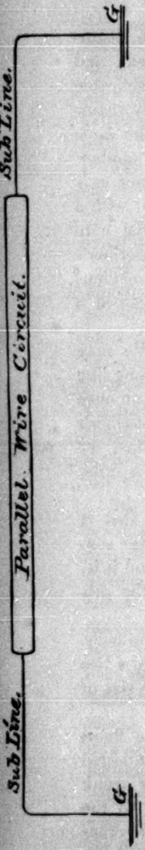
G
Sub Line.
Parallel Wire Circuit.
Sub Line.
G

PLATE A.

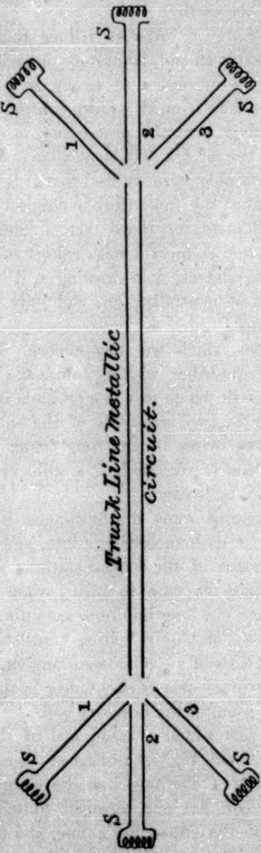
S
S
S
1
2
3
Trunk Line Metallic Circuit.
1
2
3
S
S
S

PLATE B.

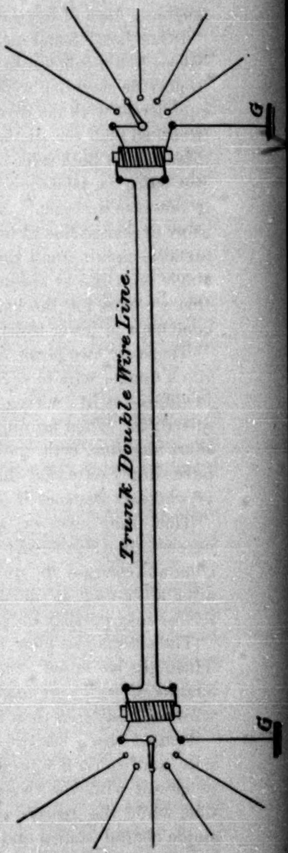
G
Trunk Double Wire Line.
G

PLATE C.

sults of the neutralization of the disturbing currents are thus obtained, these being at least minimized by means of the return wire; while the telephonic currents induce currents of like character in the coil which is in circuit with the shorter and local line, thereby reproducing the transmitted speech in the receiving telephones connected therewith.

The reason for making the two circuits of these translating coils so much more nearly equal in character and conductivity than are those of the ordinary induction coil, is that each is in turn the inducing and induced circuit—that is, the conversation is transmitted from the long trunk line to the short subscriber's line, as well as from the short line to the long metallic circuit. Each is, therefore, required to exercise the functions of both primary and secondary coil. I have every reason to believe that the first instance of the use of an induction coil in this capacity was by Mr. Thomas Watson and myself, in September, 1879, immediately after the completion of the two lines between Boston and Lowell.

We used the two lines between the cities as a trunk metallic circuit, and by means of two induction coils, one at each end, two exchange lines were inductively connected with the main line. I operated the ground circuit at Lowell, Mr. Watson engineered the induction coil at the Boston exchange, and Mr. Theo. N. Vail was at his own office in Boston, and talked with me through two induction coils.

The coils we then used were wound with both circuits approximately equal, about 250 ohms each, and were wound together from beginning to end, two wires being wound on the spool at the same time, a mode of construction which, by the way, experience has, I think, demonstrated to be the most satisfactory for inductoria intended for this purpose, and which will probably be adopted.

It is proper to note that we were led to this idea by considering the mode of using the transmitter induction coil, which was even then well known; this use, however, though analogous is not identical, for it must be remembered that in the transmitter coil the iron core is maintained during action in a state of magnetic polarization by the battery currents, whereas the currents, traversing the surrounding circuits of the translating coil, have not sufficient strength to effect such a state in the core, and the induction in these coils is, therefore, almost entirely current induction of one of the coil wires upon the other, the magnetic reactions between coil and core being necessarily trifling in character. The induced effects may, however, be intensified by separately magnetizing the core either by a separate battery coil or by a permanent magnet, and I have sometimes done this with advantage.

A third plan whereby the double line may be conveniently connected with any one of a number of short grounded lines, without depriving it of any of its virtue, has been patented by Mr. Geo. H. Bliss.

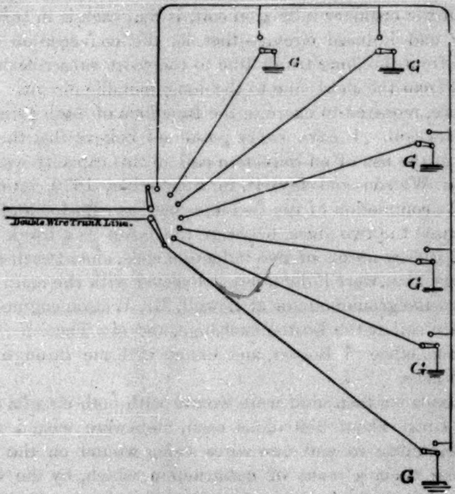

Plate D.

This is indicated by the drawing D. It consists in extending from the central station an additional line wire, which may branch into as many sub-stations as are intended to use the long double wire trunk line. Each of these sub-stations may be fitted with a button switch which, when turned in one direction, will retain the telephones in their ordinary ground circuit, but which, when turned reversely, will disconnect the subscriber's line from its ordinary earth terminal and unite it with the branch from this extra circuit, thus providing a double, although not a parallel, wire between the central and sub-station, both ends of which may be then united with the two ends of the metallic circuit trunk line.

One extra wire of somewhat abnormal length is thus enabled to serve in place of a great number. It would be easy to fit the telephone call boxes with a double gravity switch and two separate telephone receivers, one on each side of the bell box, and to so connect these switches with the circuits that it might be invariably understood that when the receiving telephone on one side is taken from its place and used, the line would be used in its normal condition, but that the other telephone, when taken up, would connect itself and the transmitter in the loop circuit. One could then be always used for short line and the other for long line work. I am very favorably impressed with this, and do not believe that it has yet had the trial it deserves.

I am conscious that this paper already is too long. I may not, therefore, on this occasion describe at length the specialties in switching and signaling appliances which have been found necessary, and have consequently developed in the practice of long-line telephony, but hope either to say or listen to something of this branch at some future time.

I have, I think, said enough to prove that long-line telephony is a reality, the *New York Times* on contract obligations to the contrary notwithstanding.

Mr. Lockwood: I might perhaps say a little upon another recent advance which has been made. It has been found that a great many telephone companies have not been able, in operating small exchanges, to get satisfactory remuneration, and it has been quite a problem with telephonic electricians to provide some simple system whereby any subscriber could readily connect his own line with any line of the system at pleasure and call up the subscriber himself. I am aware that there are a number of so called automatic exchanges developed especially on paper, but the result of nearly all such schemes is that any person trying to operate them, and any inexperienced person especially, is almost sure to connect himself with some undesirable party. It works all right on paper and sometimes it works right in practice. It is very easy for an electro-magnetic ratchet to make a slip of one tooth, and one tooth makes all the difference in the world when it comes to connecting telephone subscribers. Then when you have connected with the proper line, you must ring up your correspondent and the very act of ringing him up will be very apt to start the machine again and while you are ringing up one you are liable to connect yourself with another. In a small village they can stand thirty subscribers at a reasonable price, and one plan is to divide the thirty into six lines of five subscribers each; each line runs to all the subscribers, while its own subscribers are the only ones that have a signal bell connected. For instance if this were number One it might run to station number One, it might have a bell magnet at Two, another one at Three and so all the way through. (Illustrating on the blackboard). In addition to that, each line runs by a loop or branch into every other station. This one in addition to its signal bell will have a spring-jack containing means for introducing telephone instruments, so that he may if he pleases connect his instrument with number Four. The better way is to introduce the instruments right in, instead of having a branch. Here is a card which tells him the signal for every office on every line. If he wants to ring No. 30 or 32 he simply rings that number and he at once gets it on his own line, while the act of hanging his telephone will restore him to his normal condition. There is such a system as this in operation at Leicester, Massachusetts, with the addition of a trunk line which runs to Worcester some six or seven miles, and there is an automatic clock arrangement which can be started up from the office at this end or from any one of these offices and each has an arm running around which successively connects the long trunk line with each one of the other lines and any of the stations on any of the other lines may stop this line at any point they wish. It works very fairly in practice. But the trouble which is developed is not one of operation but is one of original expense; that is that in such a place as Leicester, Massachusetts, where a system like this would be a benefit, the people taking telephones are physicians and large store-keepers and gentlemen of means, but when it comes to the gentlemen of means they are usually straggling a long way off from the people they want to talk to and it doesn't take long to make the expense of running loops and branches equal to the expense it would be to have a competent operator at the central station. I think myself the better way would be to put some fifteen or twenty telephones on one line and if a first class individual signal can be procured, give each one an individual signal, so that any one of the stations could be cut in at pleasure either from a sub-station or from the central. But the individual signals are one of the hard nuts of telephony, and while there are to my certain knowledge one hundred and twenty-five patents on the subject I fail to realize that any one of them has gone into successful operation as yet. (Applause.)

The President: I suppose we can hardly expect that any one here would be able to add a great deal to what Mr. Lockwood has said on this subject which he is perhaps more familiar with than any other person in the country, but there may be some who would like further information about it, or who desire to ask questions and perhaps make some remarks and we would be very glad to hear from them.

The Secretary: I noticed the other day an extract from a Waterbury paper, saying that there was a movement among the manufacturers in the Naugatuck Valley, to dispense with their warehouses in New York and do the business at the shops. It occurred to me at that time that possibly the introduction of this long-distance telephony might have something to do with it, as I understand that some of those firms have made arrangements with a "long-distance" line between New York and Boston, to do their business during a period of two half-hours a day or something of the kind. I would like to inquire whether this is the case and whether they have got it to such perfection as to do their business and dispense with their warehouses in New York. Holmes, Booth and Haydens, I believe is one of the firms.

Mr. Shelbourne: In answering the question, so far as I am able, of Mr. Pope, I would say that there has been in this city for a year or two, a company that is doing long distance talking between Connecticut towns and New York city, and they have an arrangement of their wires by which they connect with the principal warehouses here—connect their warehouses with the factories. For instance, they give Holmes Booth and Haydens, or the Ansonia Brass and Copper Company, a certain interval of the day in which they can have the wires exclusively for their factories and they connect them on their iron circuits. They have, I believe, one copper circuit. In favorable weather and under favorable conditions they also use some of the iron circuits—metallic circuits.

Now, of course, that is a mere question of commercial advantage. If they can dispense with their warehouses here and do their business direct with their customers through these telephone wires, that is a question for them to determine.

In connection with this service in Connecticut, an induction coil of my invention, of peculiar construction, has been in use for some months, and that brings me to that branch of the subject that was quite elaborated by Mr. Lockwood. He spoke of the induction of parallel wires in such an induction repeater. That certainly is the case under the conditions in which he represented the matter. Some couple of years ago I conceived this way of overcoming that difficulty. I employed a core made of small soft iron wires bunched, about two and a half inches long and about a half inch in diameter. Of course when we come to the high induced current that we find upon the line in telephoning, we know that it has very little effect, because the quantity of current is not there, and the intensity does not produce that effect in the core which we might expect from a primary current in the same wire, and therefore the effect is principally due to current induction between the parallel wires. I am aware of Mr. Lockwood's efforts in that direction, and I am aware also of his use of wires for the induction repeater, one of which is somewhat larger than the other, making what is called the primary, and having in parallel circuit with it, around the core, a smaller wire, which, perhaps, may be called the secondary; but the winding of the large wire stops short of the end, and the smaller wire forms what is called an additional secondary over the large wire. Now I find that the best results, I think the best possible results —I may be mistaken in that, because we do not know what is possible in these things—are produced by having the wires exactly of the same size, so that the induction repeater is made entirely reciprocal, and to get the best possible effect out of the cores, instead of having one core, I have the cores in pairs, and these two wires are wound entirely as one, parallel of course, with the ordinary silk-covered insulation, to a very moderate extent around each of the cores, so that all the current you do get into one of the wires, which we will call, perhaps, for the purpose of illustration, the primary or the induction-giving wire, produces its best effect with a very small thickness around the core. Then the cores are associated with each other, and the spools containing these parallel wires are placed on ends, so that the cores will have the north and south poles adjacent. Then the wires being connected with the posts of the instrument, the two spools, if there is only one pair, are associated with each other, the one with the north pole adjacent to the south pole of the other, and the two are enclosed in a soft iron case or box, but before that is done a plate is put upon the base of the instrument, a soft iron plate, but which is separated from metallic contact with the cores, and in putting the cover upon the oval box, the covers forms a soft iron plate at the top; the whole is fastened together by a brass rod, screwed down through the base of the instrument. Such an instrument as that has been used for months, as I said, in connecting with those Connecticut towns, and working between those towns and the subscribers in New York, such as the Ansonia Brass and Copper Company. It has also been used experimentally between New York and Boston. Of course the lines of force that emanate from the cores produced by the induction-giving circuit are, in such an instrument as that, condensed, and they are made to cut relatively the wires around both the cores. Now the question arose in connection with this instrument that, whether using it in connection with a metallic circuit between exchanges—Mr. Lockwood has very happily explained the advantage of a metallic circuit in avoiding induction, and also the necessity of having the wires associated, so that their induction-giving and induction-receiving effects would be from the same line and distance in space—such an instrument put in the exchanges at either end of a metallic circuit thus arranged, would repeat the voice from a subscriber inductively at one exchange, however distant, within working limits, to a subscriber connected inductively with the other exchange. But in presenting and testing this instrument in this city connected between metallic circuits, (although they were not twisted together) and ground circuits at either end, the question was suggested by the vice-president of the Metropolitan Telephone Company, whether it were possible to ring up the subscribers inductively through such an instrument as that. Well, I said that was a question I could not answer. So in connection with the electrician of the Commercial Cable Company, although we could not get the battery which was in use with the pole changers in the exchanges because they were continually in use, we put up the same kind and amount of battery used upon the single trunk line circuits here in ringing up subscribers at either end. That is, we found in one exchange two gravity cells for quantity and ten for series, making twenty cells, and without the advantage of the pole-changers and through the ordinary magneto, we found that this induction instrument would operate perfectly, that is, we could ring up the subscribers from a metallic circuit with the same effect as we can now through a single trunk line.

In regard to the two limbs of the metallic circuit, not giving induction from the same distance—the experience of the countryman referred to by Mr. Lockwood is not altogether unique, for I could mention here some persons who are considered pretty well up in electricity, who started a line in Ohio in the early experience of telephony and that same question arose. In connecting Cincinnati with some other towns they did the same thing, they got up a round detour circuit, and the question was, how it was they did not avoid induction. Of course the thing is explainable very easily. You may run a metallic circuit around in a circle and you may get more induction, as Mr. Lockwood has said, than if you had a ground circuit.

The President: There was one point I did not quite understand from Mr. Lockwood's paper. I would like to ask whether the variable resistance of the transmitter is in the same circuit with the primary of the repeating coil, or whether it works on an induction coil in the transmitter as usual, and that coil works on the repeating coil, so that there are three induction coils in the circuit.

Mr. Lockwood: The transmitter is fitted up with its own low resistance primary coil, and the secondary current repeats itself through the translator. There is little loss through the translation except at first. There is certainly a small amount of loss with this translation, bnt nevertheless the system will be practicable for commercial use. I can corroborate what Mr. Shelbourne says—it is very easy to ring a bell even through the two induction coils; even by simply making a break in the original battery circuits the impulse is reversed.

Mr. Shelbourne: Our experiment was successful without the pole-changer, because we did not avail ourselves of that.

The President: I might remark in reference to this question of the loss in conversion in the induction coils, that some experiments that I have recently witnessed in another branch of electrical work, which it would not be proper for me to give the particulars of at present, showed that with a properly constructed induction coil the loss in conversion is exceedingly small, so that I think there is good reason to suppose that by further researches some particular form of induction coil or mode of construction may be found in which this loss by conversion may become very trifling. Probably it will not be sufficient to be noticeable unless there are quite a number of transformations—quite a series of them. I should think from what I have observed in this matter that it is probable that the loss in three conversions could be brought down within ten or fifteen per cent of the total effect.

Mr. Jones: It would hardly be in keeping with the intelligence of the members to make any reflection upon the ability with which Mr. Lockwood has dealt with this subject, but of course after a good hearty dinner we want a little charlotte-russe, and I suppose it is the duty of each one of us to contribute to this subject while it is under our consideration. I happened to use the two first instruments that Mr. Gardiner G. Hubbard took to the west, and made the first experiments on them I believe early in 1877, and we talked readily two hundred and forty miles, and a distance of twenty miles regularly every Sunday. We put them all in circuit in a room, having a piano and a flute and an accordion, and different instruments, and had them all going at once, and somebody talking at the other end, and we could get the whole menagerie right there. We got up a musical telephone at Cincinnati, which you know is about three hundred miles off, and we were able to produce these musical sounds in one of these box relays to perfection. The Governor and Secretary of State, and all the electricians round about for miles, came around and heard it. We had a little cigar box with a slit in the top, into which they dropped a nickel, which started it; and I believe we made enough money to pay the expense of the scheme. We called up the chief operator and asked him to connect Cincinnati and start the musical telephone. By means of a button under the counter we set it going. We had a little music box inside. (Laughter.) As to the other scheme they had out there, I don't know how well it worked. I know I was in Chicago at the time and had charge of the office, and if any such conversation went through the office it was when I was sound asleep.

In regard to working circuits with a great many instruments in, we tried in the early days in Chicago to consolidate them into one line, and by putting a little coil of resistance around the electro magnet or receiving instrument, we rendered it less opaque to the voice vibrations than if they had travelled all around the convolutions. Another plan we had was to split the relay. I think that is all I can contribute to the subject.

The President: If there are no further remarks to be made, we will proceed with the next paper, which is on the subject of "The Patent Office and Patent Office Practice," by Mr. Fowler, formerly one of the examiners.

THE PATENT OFFICE AND PATENT OFFICE PRACTICE.

BY A. C. FOWLER.

At the request of the council of the Institute, the following paper has been prepared.

At first I was at a loss to know why I had been called upon to write something on this subject, thinking that this would be assigned to some older member of this society, who had been longer in practice before the patent office; but the honorable secretary informed me that I had been called upon because of my experience as an examiner in the patent office, and especially in the electrical division, and could handle the subject from the standpoint of an examiner as well now as an attorney (although one of several months standing only), and could express myself freely, inasmuch as I had now severed my connection with the patent office.

It was my intention a month ago, upon receiving the invitation, to give the subject much thought and attention; to compile statistics and to review decisions at some length; but I regret to say that the pressure of business has compelled me to abandon such an undertaking, and to content myself with making some observations on this subject which I trust will prove of interest.

One of the first things desirable, indeed we may say imperative about any practice in whatever jurisdiction, whether it be in equity, at common law, or before the patent office, is stability. I have several times heard lawyers remark that they could get along all right in the courts, but that the patent office was too much for them. It is often remarked that courts adhere too much to old forms and to old practice. The advantage of this is upon a little reflection readily seen; you always know where you stand; you know that the practice to-morrow will be the same as to-day. You are not told in a decision to-day that process and apparatus can be claimed in the same case, and by another decision to-morrow that this cannot be done. Under a decision to-day you are not given all information necessary to go into interference with a pending application if you choose, and by a decision rendered another year, all information whatever concerning an interfering case is withheld from you. Nor would you have to submit to such a thing as a strict interpretation of the statutes and rules regarding interference one year and loose interpretation another year. Nor would an oath that was formal one year be declared informal the next. Nor would you have to limit your claims to "*means as described*" and by the practice one month, and by the practice a few months later find that you are not required to so limit them. Nor would you be harassed and annoyed by startling innovations every month or so by an issue or draftsmans' division. By such a practice you never know where you are, nor whether you will be in the same predicament to-morrow that you are to-day.

So you see there is some advantage in having a practice and a law like the old unwritten common law and practice that has been handed down to us by England, and extends back to a time whereof the memory of man runs not to the contrary.

Under such a practice an attorney always has the law and the practice within easy grasp. He is always competent to advise his client. The practice is uniform and unvarying to a great extent. The practice of the patent office on the other hand is irregular and unstable. I say these things not to cast any reflection upon the officers of that bureau, nor to disparage the work done by this office, for I have the highest regard for them and for the arduous duty performed by them; nor am I unmindful of the serious disadvantages under which they labor. Neither would I be understood as not favoring progress and the removal of bad and unjust rules and laws in regard to patents, and the improving of the patent office practice by establishing new rules and precedents and by rescinding and overruling bad ones; at the same time I cannot help but think that the patent office practice needs reforming and that more stability of practice would be one of the greatest steps towards this.

There is another thing in which the patent office appears to excel, and that is—the facility with which one tribunal or examiner overrules another. There is, I believe, nobody having judicial functions in which opinions and decisions are so often reversed and overruled—so little regard for precedents. The want of concurrent decisions in the patent office appears to be remarkable. This tendency to reverse is so marked that some of its officers have been known to sometimes overrule the U. S. Supreme Court. It may be that this is to be looked for where there are so many questions of fact, as well as so many questions of law and practice, with so many tribunals to take cognizance of the facts, interpret the law and decisions, and administer the remedy.

The want of stability of the patent office practice above referred to, it appears, results from several causes:

First. There are so many independent tribunals or heads to interpret the law and decisions.

Second. Some of those who are called upon to interpret the law and to apply the decisions fail to discriminate legally, but apply decisions alike to all states of fact, whether a different state of facts exist or not. To act judicially, and to apply decisions and decide questions involving legal points, one must, of course, be legally equipped to some extent and possess a certain legal inclination, and be capable of making nice distinctions, so as not to apply decisions and rules indiscriminately and misapply references. So that an examiner should be something in a judicial way as well as a man versed in the arts and sciences. Some of them are undoubtedly too narrow and illiberal, and should broaden their ideas a little. Some of them seem to act as if they were placed in their positions by the government not to grant patents, but to antagonize and harass inventors. These examiners act upon the principle, which is contrary to the legal maxim, that it is better to let ninety and nine meritorious case suffer than to let one unmeritorious one pass. The question with these examiners is not *how to do* but *how* NOT *to do.* They forget that they are placed where they are by the government to facilitate and expedite matters—not to impede and obstruct—and that they are there to grant patents, rather than not to grant them. Of course a case should have a rigid examination and not a lax one—for the better, the more thorough the examination, the better for all parties concerned.

Third. Many of those in responsible positions have not had sufficient time to become versed either in the patent law, the practice or the arts. This results from the fact that many resign to go into practice in the various arts in which they become proficient in the patent office, owing to the fact that the government does not pay them enough to retain them, and they seek a field wherein they can make more. It is rare that a commissioner remains at the head of this department over a few years. He is called upon to act judicially as well as ministerially, but does not remain long enough to become well acquainted with the law or practice. The salary of this officer should certainly be increased considerably over $5,000, his present salary. He has so much to do of an executive nature that he has not sufficient time for judicial acts. The latter should no doubt be taken from him by statute, and be made to devolve upon some other person or tribunal appointed for this purpose. By this means the practice of the patent office would be rendered more stable. All the examiners in the office should then be required to adopt the rulings and decisions rendered by this tribunal, instead of interpolating their own ideas and making their own precedents.

Politics, which is generally in the interest of a few and not of the many, also operates against the efficiency of the patent office. I know of no bureau under the government, however, that is freer from the plague of politics than this one; yet politics does militate against it in more ways than one.

Of recent years examinations for promotion have been abolished, but I am happy to say within the last month they have been revived. While competitive examinations are not an absolute test of a man's capability and efficiency, they have proved to be the best system for the patent office. It was urged during the existence of the competitive examinations for promotion that the examiners spent much of their time studying up, to the detriment of the service. Since competitive examinations have been abolished they have wasted more time trying to get promoted. By the first system what the man gained by studying up was gained by the office, but by the scramble-for-promotion system the man gained nothing that benefited the office; in fact the office lost, for this system of promotion which did not investigate the merits of men, could not be a test of fitness. The patent office, however, has always held competitive examinations for appointment to the examining corps, and of recent years graduates of scientific schools and scientific men generally have been notified of such examinations in order to give them a chance to compete. By this system the examining corps has been recruited from men who are well fitted to fill these positions.

Many, however, have been given positions in the examining corps within several years past, contrary to precedents and without examination. The method of doing this has been to give the person a position as laborer in the department, or some other minor position, requiring no examination for appointment, and inasmuch as there is no rule or law governing promotions, to promote the aforesaid person in a few months to an assistant examiner. So that where many of scientific attainments have been turned away because not able to pass the rigorous examinations for appointment, these favored few have crept in.

The question is: How can these evils be eradicated; how can the system be improved and how can the rapidly changing personnel of the examining corps be made more permanent. The last can only be done by raising the salaries of the examiners. A principal examiner gets but $2,400, and his first assistant but $1,800, and so on down. How can this office hope to keep men who are expected to know the law and to be versed in the arts and sciences at such salaries? These matters can only be reached by Congress and Congress can only be reached by votes. Those of you who are interested in these and kindred questions concerning the patent office and the patent practice, as well as all manufacturers who are interested in patents, should demand of your representatives and senators that these evils be remedied. Make it a question of votes and you will accomplish something. The average official life of an examiner in the electrical division is rarely over three years, and as soon as he becomes skilled in this art he seeks a more remunerative occupation. This division is subject to more changes by reason of resignations than any other.

By carefully conducted but not too rigorous competitive examinations upon technological and scientific subjects, and the exercise of good judgment, for admission to the corps, and an examination upon these same topics and the law and practice for promotion, only those will reach responsible positions who are qualified to answer all requirements, and must therefore give satisfaction.

The patent office ever since its establishment has been, as you all know, a self-supporting institution. Being so it is difficult to understand why it is treated so niggardly by Congress. The reason is, because you have not made it a question of votes. It is in fact more than a self-supporting institution. Out of the patent fund has been built one of the largest and most imposing buildings in Washington ostensibly for the patent office; but this office is permitted only to occupy a small portion of this building, the major portion of it being occupied by the interior department and its other bureaus, which have never paid anything to the patent office or the patent fund for the use of this building. This office occupies the most undesirable portion of the building, and is hampered in its work by being overcrowded and the health of its employes seriously endangered thereby. The patent office owning all the patent office building should have as much room as it needs in this building, and Congress ought to see to it that the bureaus of the interior department which are located in it and take up the room needed by the patent office, be required to move into quarters of their own, provided for this purpose.

Why should inventors be taxed for the benefit of the other bureaus of the interior department? Why should there be a surplus of receipts over expenditures each year in this office? Should not the money received by the government for a given purpose be expended for that purpose? Should not all the money received for the patent bureau be expended for this bureau and for the good of the service and not diverted from its purpose? There is only one answer to these questions, and the government acts in bad faith when it receives money for one purpose and expends it for another. You are aware, perhaps, that the electrical division has no electrical appliances to speak of, with which to test apparatus. They have asked and asked again for a laboratory, but in vain. Every division in the office needs men, needs facilities, needs everything.

The patent office is said to have to its credit, in the treasury of the United States, about $3,000,000. It has been proposed by Congress to appropriate this surplus for educational purposes. While it could not be diverted to a better purpose there is no reason why all of this fund should be used for the above purpose. I am told that some years ago, an assistant commissioner investigated this question of the surplus of the patent office, and found that as a matter of fact, if due allowance had been made in years gone by for printing done for this office by the government printing office at public expense, that this would about offset the surplus of three millions. This money of course had to be appropriated by Congress for the printing office, and in this way Congress was really making appropriations for the patent office through the government printing office. In recent years the cost of all the printing done for the patent office by the printing office has been deducted from the patent office receipts, but even now there is a large surplus of receipts over expenditures every year, which in some years has amounted to several hundreds of thousands of dollars. So you see that the patent office formerly was about self-supporting only, but of recent years is more than self-supporting. Now if the interior department had allowed the patent office anything for rent of its building, the patent office would nevertheless have a large surplus to its credit in the treasury; but if all the money now received be expended for the patent office, so as to make the expenditures equal to the receipts, you should feel satisfied, as the service would by this means be very much improved.

Either this should be done or the patent fees should be reduced, for by the present system the government is imposing a tax on inventors, which, I take it, was never intended to be done. The idea of taxing patents is a foreign one to us. It is the course pursued by foreign countries, and tends to check invention and deter inventors from taking out patents. This is attested by the growth of inventions and patent interests in this country, which exceed by far those of any other nation in the world. It is not that American inventors are more ingenious than those of other countries, but because the inventors are not taxed as they are in other countries. A tax upon the patentee was never intended by law. A patent is in no sense a monopoly.

The fees for patents in this country are surely small enough, and every inventor, I think, would be glad to have them remain as they are, if all the fees were paid out for the good of the service. It is the salaries of the examiners which should be increased.

Now then, you say, suppose the American system remains as it is, what is going to become of it? The chances are that it will go along as it is, unless some steps be taken by you and all of us to prevent it. Each day the examinations in the patent office are becoming more a matter of form and less a matter upon the merits. This cannot be helped with the amount of work on hand and the force to do it. Every day our patent system is becoming more like the English system and the systems in other foreign countries, where no examination on the merits is made, and where a patent gives you no *prima facie* right to the thing patented. The distinctive features of our system are rapidly passing away, and it will not be long before the patent office examinations will be formal only, and our patents will have to be sustained in the courts before they are worth anything. Every day less and less importance is attached to a patent in this country. This rapid approach of the American system to the English and other systems will go on until the patent office gets to be but a mere registration office.

The tendency of this will be to increase the business of solicitors and patent lawyers. The former will be called upon under this system to make the examination on the merits, which was formerly done by the office, and draw up the papers in accordance therewith, and the patent lawyers will have more suits to bring; so that this system will bring advantages to some but will be disadvantageous to others. On the other hand, capitalists will be slow to take hold of or buy up inventions, and thus the patent interest will suffer to a marked extent. For one, I shall be very sorry to see such a change.

Regarding the value of caveats, it may be said that they are practically of no use. I generally advise those who ask my opinion, notwithstanding it is prejudicial to business, not to apply for a caveat. A sketch of an invention, with perhaps a short description and a witness or two, in the hands of the inventor will afford as much protection as a caveat. As a matter of fact, but little attention is paid to caveats by the office, and they are often overlooked. I only remember having notified one caveator to complete his invention during my experience of over five years in the examining corps, and then after he had completed his invention within the three months allowed, it was totally different from the other party's. This is about the only instance in which the patent office takes your money and does not give you an equivalent. It seems that the law relating to caveats could very properly be repealed. They cannot in any way prevent an interference, and inasmuch as you can go into interference with a case just as well after it has been patented, you can see that a duly witnessed sketch establishes your date just as effectively as a caveat, and does not cost ten dollars.

It is encouraging to note that reissues in the courts and in the patent office are beginning to be looked upon with more favor. The decisions in the Giant Powder Company *vs.* The Vigorit Power Company, James *vs.* Campbell, Miller *vs.* Brass Company and others, went to about as great an extreme in one direction as did the patent office formerly in the other in granting reissues. There is, no doubt, a middle ground upon which they can safely rest. The question as to the advisability of reissuing is one requiring much thought, and can never be absolutely free from doubt. It does not appear to depend solely upon the time elapsing between the discovery of the mistake and the time the reissue is applied for. Of course laches is taken into consideration, but the question depends somewhat upon whether intervening rights have accrued in the meantime. Where none have accrued, and the time is not unreasonable, the question is easily settled.

The question of interference is a perplexing one to many, but the proposition is a simple one. The one first to conceive is entitled to the patent, *provided* he is using reasonable diligence to perfect his invention. It of course makes no difference whether another perfects the invention first, as long as you are the first to conceive and are using reasonable diligence. Neither does it, of course, make any difference whether the other party has obtained a patent, for it is invalid if you were the first to conceive and have been diligent. Whether the old system of interferences is better than the present system is a question upon which a great deal can be said on both sides. Parties now, as you well know, are not placed in interference until they claim the same subject-matter. Previously when one party made a claim that the other one could make, but who only showed and described the subject-matter, the former was notified of the other's claim, and given a certain time within which to amend his claims if he chose. By the system now in vogue many cases go to patent which ought, as a matter of fact, to go into interference, instead of giving a patent on substantially the same thing to each party because they did not claim exactly the same subject-matter. So you see by this system a great many patents are now issued which show and describe the same subject-matter, and thus a confusion arises, and this casts odium upon patents. By the old system a bad attorney, who did not know how, or take pains to claim the invention properly, got the benefit of a good attorney's work; besides, people are supposed to know what they have invented, and they are at liberty to claim what they wish, and this is their own lookout. The present system was inaugurated a few years ago, at a time when the interference division was overrun with interferences, and this course, it is said, was adopted to relieve this division. Since its adoption the number of interferences has decreased materially, and cases are often now held by the office for months waiting for parties to claim the same subject-matter. The office, however, is now very liberal in construing the rules relating to interferences in view of certain decisions, and claims under the new system are now placed in interference whenever they can be construed to cover the same subject-matter. But even under this practice many cases go to patent which should in reality be placed in interference. Of the two systems, therefore, it seems that the old system is preferable.

The decisions in *ex parte* Blythe, which held that process and machine could not be claimed in one and the same case, as you may be aware, has been overruled. This indeed is a step in the right direction; for this decision brought about some absurd results. The test in these cases as to whether a process and product or machine can be joined in one application is: whether they are inseparable, that is to say, if the product can only be produced by the process or method, and no other process or method is known by which the product can be produced, then they can be joined in the same case. So too, if the process or method is inseparable from the machine and the working of the latter carries out the former, and no other means are known by which the method could be effected, they can be allowed in the same application. Of course the method must be something more than the mere necessary operation of the machine. So where a machine produces a product and no other machine or method is known by which the article can be produced, it can be claimed in one and the same case with the machine. So too where the method, machine and product are inseparable as pointed out, they can be joined in the same case.

Just what a method is, is difficult to say. The term is used as synonymous with process, but the word "method" refers generally to mechanical processes or operations. A method has never been clearly and fully defined, and whether a claim is for a method or for the operation of a machine, or whether in fact it be a method at all, are matters upon which there is much diversity of opinion. Some say method claims should be wholly independent of any means, and not limited by the means whereby the method is accomplished, but this must be received with some allowance; for it is well-nigh impossible to draw a method claim without specifying some means. Some say on the other hand, that a method claim cannot cover anything that is automatic. That as soon as you introduce the word "automatic," in a method claim, that it becomes in whole or in part a claim for the operation of a machine; for they hold that whatever is automatic depends upon the machine itself, and does not depend for its operation upon the exercise of thought or volition, and hence cannot be said to be within the term "art" used in the statute. It is difficult to say whether this is to be accepted, and in some cases it is not seen how it can be received. These method claims are very much in vogue just now, and as electricity is known and defined by its functions only, and as it is difficult to define sometimes an electrical invention in any other way than by its functions, the method claim is very common in the electrical division. These claims certainly come nearer covering principles of operation and functions than any others that are allowed. Some also go so far as to say that there can be no such thing as a joint invention, and they hold the idea of joint inventorship, as a matter of fact, an absurdity.

To tell what the office considers a functional claim is difficult, sometimes it's one thing—sometimes another. It is granted, of course, that where elements of the combination are specified, and their functions added, that this does not render the claim functional; but where there are all functions and no means, or where a result is specified without stating any means, or sufficient means, the claim may be said to be functional, although the latter is said sometimes to be a claim for a result. I think it will be admitted that the nearer you come to claiming the functions or the principle of operation of your invention, the better you are protected. In fact, to claim a thing functionally is the easiest and clearest way of defining an invention, but since this is not permissible, one must content himself by protecting his invention as best he can. Under the German system it is deemed advisable to make the claims few and functional, and, as you well know, they hold very strict examinations there, and concerning questions of patentability and matters of form are very particular.

How to claim an invention is a question. The claims as you know are the vital part of a patent. You are well aware if a man describes and shows a dynamo machine in his patent, but only claims the commutator, that the patent is good only for the commutator, so you see a man may invent, describe and show a very good invention but claim a very poor one. Whether a few claims will do or whether many would be better is a question. It is always safe, however, to err on the right side, and it seems that claims ought to be drawn somewhat like the counts to an indictment; so that where you fail as to one, you may prevail as to another. It seems to be a good plan to draw your claims as broad as possible, and then to put in claims a little narrower and so on down, until you reach the exact construction of your apparatus, so that should it happen that some of your claims are too broad or do not interfere with the claims of a pending application even, you can rely or fall back on the remaining ones. The graduating of claims in this way seems almost a necessity. It is not meant by this that claims should be unnecessarily multiplied or too numerous, yet redundancy, you know, does not vitiate.

There is another thing, and that is, you must not accept every rejection of the patent office as a good one. The spirit of acquiescence must not be too strongly marked in you, else you will not get what you deserve. On the other hand, you must not waste time unnecessarily antagonizing examiners and wrangling over small and unimportant points. You must fight, but you must fight for something.

The examiners of the patent office are often censured by patentees and assignees of unexpired patents for granting certain patents. These persons are continually finding fault because subsequent patents have been granted which conflict with their patents. These parties make a mistake that is often made, that is, they do not distinguish between patentability and infringement. The patent office deals with questions of patentability only. It is not the duty of examiners to pass upon the question as to whether a subsequent patent is tributary to your prior patent, or whether it is an infringement, or whether a claim is broad enough to include a subsequent one. They decide whether there are any substantial differences and whether these differences are new and useful, not whether the subsequent patentee has to make use of your invention before he can use his own embodying these differences. A thing, of course, may be patentable, and yet an infringement. The courts only deal with both of these questions.

The limiting of patents to expire with the expiration of the first expiring foreign patent previously granted is a section of the law that still remains unrepealed, although much has been written and said on this subject. There is no reason why this limitation should exist, and it should therefore be removed.

The question often arises when is the best time to sell an invention or patent right? This time is, I think, while it is pending in the office, after the case has been allowed, and when it is yet in the issue. An invention at this time seems to command more respect and a better price than at any other time. It seems at this time to be surrounded by a halo as it were, and as soon as it becomes public by reason of patenting, it seems to lose in value and respect. Before the case is allowed there is doubt about its being allowed, but when it is allowed, you know that as soon as you pay your twenty dollars you can have a patent. At this time also it is best to apply for your foreign patents, and you have six months after this in which to do it, as you know.

One is often in doubt whether it is safe to exhibit an invention before patenting. Experience in the office and in the interference division has taught me that interferences between independent and original inventors are rare. They are generally between employer and employé, or between men working in the same shop, or between those who have in some way seen or got an inkling of another's invention. There is of course some risk assumed in exhibiting an invention while in the issue, but not a great deal; here you have the matter to some extent within your own control, for as soon as you find out that some other party is inventing in your line, you can pay your final fee and your application will go to patent. Before the case reaches the issue you of course do not know whether you can get it through, or how long it will take you to do so, and it is therefore not safe to show the invention at this time except to reliable parties. Interferences, I suppose, are as frequent, if not more frequent, in the electrical division than in any other. Inventors in this line seem to exhaust one field and then take up another. Each watches what the other is doing and keeps pace with the literature on the subject, which often directs them in the same channel.

Not more than ten years ago the electrical division was a small portion of the division of measuring of philosophical instruments. To-day it is about twice as large as almost any other division, employing in all nine examiners: one on dynamos, motors and regulators, one on locomotion, telephone systems and calls, one on telephones, one on telegraphs, another on arc lights, another on incandescent lamps and systems, still another on batteries (primary and secondary) and alarms, and two on miscellaneous classes. Until within not many years ago telegraphy in one form or another constituted almost the whole class of electricity. The number of inventions in this latter class has been steady from the first and holds its own to-day. The applications for arc lamps were at one time very numerous, but have now fallen off. Secondary batteries with which the office was at one time flooded have now fallen off to almost nothing. Invention in dynamos, regulators, telephones and incandescent lamps is steady; while motors and locomotion appear to exceed all others just now. The various methods of signaling with electricity, including clocks, are quite numerous. There have been about ten thousand patents granted in the electrical art already, and the outlook for electrical invention seems very bright still—brighter than ever before.

The question of modifications (which was discussed at the last meeting of this society) is easier of solution than some others. A man of course cannot wait until he invents all the modifications or species under his genus, if he did some one else might get a patent while he was doing so. If you secure a good broad generic claim and are the first one to occupy the field why will not this answer all practical purposes as near as possible? If any one else invents a modification of your apparatus it is, of course, tributary and subsidiary to your patent. His modification is covered by your patent. Now, of course, it would be well for a man to suggest all the modifications possible, but there is sometimes no limit to modifications. An inventor ought undoubtedly to take out subsequent patents on all the good and substantial modifications he afterwards invents so as to fully occupy the field, even if these other inventions be tributary to his invention, as this is sometimes a question of doubt, though not often, and sometimes you can be very much annoyed by patented modifications in adverse hands. It is often doubtful whether one thing *is* a modification of another, and very often you are called on by the patent office to divide out subject-matter which *you* think is a modification. Of course, if the latter operates on a different principle from the other subject-matter, and a generic claim cannot be secured which covers both or all, then they are not modifications of one another, but are separate and independent inventions. It is not an easy matter to determine these questions sometimes.

What can be included in one application is also difficult to say. If several things have a special community of operation, that is, if one is specially adapted to be used with another, and cannot be used generally with other devices, then they can be joined in one application. In these latter cases also, the patent office often calls for a division.

It seems best, in order to cover modifications as much as possible, to put in your specification something like the following That you do not limit yourself to the apparatus shown, as the apparatus may be varied and made in various forms without departing from the spirit and scope of your invention, and that you reserve the right to make such changes in practice as fall within these limits.

The advisability of taking an appeal is sometimes under consideration. Examiners are, as a rule, quite fair, except in some instances. Each has his peculiarities. It is of the greatest importance to understand your examiner in prosecuting a case. What will be allowed by one will not be allowed by another. It amounts to a study of men as well as to a study of practice of your case. An appeal is scarcely warranted unless you have a *bona fide* grievance and are being seriously wronged. It might have been adverted to in the previous remarks, that there does not seem to be enough intercourse and exchange of references between different divisions of the office. Each division regards itself somewhat in the light of an independent sovereignty, exercising an independent and exclusive jurisdiction, and claims are sometimes allowed by one division which could readily be anticipated in another.

Among the needs of the patent office might have been mentioned the want of some means by which to investigate the question of public use. This office has no means whatever of getting at this question, except in interfering cases. This is an extremely perplexing question to handle, nevertheless it would seem that this office should have some means whereby this matter can be looked into. The patent office is often censured for granting patents for old things—things that have been long in public use—yet if these things are not among the records in the patent office, and are not within the knowledge of an employé, there is no other course to be pursued—a patent must be granted. An application for a patent under the law and practice is an *ex parte* proceeding, and no notice is taken of affidavits filed in opposition to the grant. The American system might with advantage adopt something like the English system, wherein any interested party is allowed to oppose the grant of a patent upon good and sufficient grounds, all applications for patents being duly advertised before hand.

It is of the utmost importance to have your invention illustrated by first-class drawings, which show clearly every feature and modification of your invention. This is rendered imperative, for the reason that examinations by the office of the antecedent state of the art are made from the drawings almost entirely. Specifications are rarely consulted, except when there is doubt about what the drawings show. So that where you get a patent and do not show clearly and unmistakably every feature, some subsequent party may possibly get a patent for what you have so described. Of course you are aware that every modification described, unless it be an obvious one, must be illustrated in the drawings. So that it does not do to suggest a modification unless you illustrate it.

Before closing, I cannot refrain from paying a high tribute to the examiners of the patent office. I would not have you think, from any of the above remarks, that I am unfriendly to them or have had cause to say aught against them, for my relations with them, both in the office and out of it, have always been of the most friendly and cordial nature. I have often expressed the views contained herein while a member of the corps. Their lot is not altogether a happy one. You have no idea, I am sure, of the amount of bad grammar they are inflicted with, and the quantity of bad spelling, and the ignorance they have to contend with. The idea has been suggested that specifications should be printed as they are written, without official corrections, so as to show the public just how skilled some inventors and their attorneys are. The idea is not a bad one. You would scarcely recognize some specifications before and after they have received an official dressing.

You know, of course, that the patent office acts only on what is put before it. It does not suggest claims and the like, or supply defects, except when they are matters of form, and rarely then. Examiners are therefore very often blamed for the ignorance and mistakes of others. The patent office undoubtedly ought to have some requirements for admission to practice before it. The requirement of the rules of practice that any person of ordinary intelligence can practice before this office is absurd. Every one comes within the limit of this restriction. If some good regulations were adopted in this line, the office would not be two or three months behind in its work, as it is to-day, for much extra labor is thrown upon the office by the very ordinary intelligence of many of those practicing before it.

I thank you for your kind attention, and close, hoping I have not wearied you, and offering you an apology for the hurried manner in which this paper has been prepared.

The President:—I am sure we have listened with a great deal of pleasure to the very able and interesting paper of Mr. Fowler, which is the best presentation I have ever heard of some of the principal defects in the present administration of the patent office. He has pointed out also what is the prime cause of those defects. The difficulty being outside of the patent office, it lies with Congress. As a practising solicitor before the patent office for a good many years, I can endorse almost every word of what he has said. I think that this paper will be of a great deal of value to all our inventors, and nearly every electrician nowadays is an inventor and patentee. It is not as well known, as perhaps it might be that three-fourths of all the manufacturing business of the United States is founded on patents in one way or another, and it is very surprising that the manufacturers and patentees, constituting so very large and important a portion of the population, do not concern themselves more with this matter, and pay more attention to it and urge it upon the attention of Congress. No reform will ever be brought about of any importance until the people interested and who suffer by these defects will wake up and determine to have them corrected.

The paper is now before you for discussion. If no one wishes to say anything upon the subject presented, we will proceed to to the reading of the next.

The Secretary:—The next paper in order is on Static Difficulties in Telegraph Wires, by Mr. F. W. Jones, who has made it the subject of study for a great many years.

Read before the American Institute of Electrical Engineers, May 19, 1886.

STATIC DIFFICULTIES IN TELEGRAPH WIRES.

BY F. W. JONES.

The subjects of electro-static and electro-magnetic induction, having so many distinct features of considerable scope, each of which is treated at length in the various text books, it is not possible, within present limits, to do more than furnish a few of the recorded methods of overcoming the detrimental effects of induction upon signals over land and ocean wires.

Briefly stated, the detrimental effects are as follows:—On a long submarine cable it is impossible to record upon the most delicate instrument, a signal at the distant end at the same instant that it is given at the sending end, notwithstanding that electricity may be said to have a velocity too great to be assignable. This retardation in the cable is due to what Faraday, Siemens, Varley and others, in early days, termed the electro-static induction. The current, if sent into the cable in a succession of dots of equal duration and at equal intervals, will be prolonged to dashes at the distant end, commencing very faint, rising to a maximum strength, and then gradually tapering off at the close, after the battery has been removed. Should these dots be sent at shorter intervals they will appear at the receiving end as a continuous dash. When dots of the same duration and periodicity are sent through cables of the same length, their speed varies inversely as the product of the resistance and inductive capacity of the cables respectively, and the time of charging and discharging a cable varies inversely as the square of its length. Not only does the cable retard the signals, but the convolutions of the electro-magnetic apparatus, inserted in the circuit for the purpose of recording the signals, also exercises a retarding action on the current, due to electro-magnetic induction. As the signaling current passes around each one of the coils, there is an antagonistic or extra current aroused in all the adjacent coils flowing in a direction opposite to the signaling current, which it tends to extinguish and delay. In the straight conductor of the cable there occurs a similar but weaker effect. When the differential duplex system is applied to a cable there are, necessarily, sending and receiving instruments in circuit at each end, and instantly, after a signal is sent from one end, a ground is substituted for the battery, so that from the electrical centre of the cable near mid-ocean the current in the cable will divide, only about one-third of the current passing out at the distant end, and about two-thirds, returning through the ground above mentioned, at the sending end. As the receiving coils are always in the circuit, this returning current will produce a "kick" or false signal unless neutralized. The above-mentioned difficulties are experienced upon land wires, but in a much less degree, dependent upon the length, size and character of the wires, and their proximity to the earth and surrounding objects, and of the size and number of electro-magnets employed in circuit. There is also between parallel land wires an additional and serious difficulty, due to electro-magnetic induction, the magnitude of which depends upon the length and insulation of the wires and their distance apart, and on the strength of the signaling current, and the character of the signals.

About 1831, Michael Faraday coiled two insulated copper wires together around a block of wood, and connected one helix with a galvanometer and the other with a battery of 100 pairs, and discovered that when the battery contact was made and broken there was a sudden effect upon the galvanometer; "but that whilst the current continued to flow through the one helix, no galvanometrical appearances, nor any effect like induction upon the other helix could be perceived."

Faraday also discovered at this time all the other fundamental phenomenon of electro-magnetic induction. Nearly at the same time Joseph Henry discovered the phenomenon of the induction of a current upon itself in a long-coiled conductor.

M. Jacobi, of St. Petersburgh, Russia, is credited with being the first to introduce in a circuit a polarization battery, consisting of platinum immersed in sulphuric acid, for the purpose of counteracting the injurious effects of the residual magnetism in the electro-magnets. The line on which this was tried extended from St. Petersburgh to Moscow.

Werner Siemens published a very valuable article in the *Jour-*

nal of the Society of Arts, April 23d, 1858, in which he ranks as one of the earliest investigators upon the subject of the static charge of underground wires. The following are some extracts from both English and American patent records, showing a variety of inventions for overcoming static difficulties, and I leave to those skilled in the science of patent law all questions relative to the validity of the patents or priority of the inventions.

Eng. Pat.

13062. **E. W. Siemens**, Sept. 23, 1850.

To prevent the wire from being charged with electricity (in the manner of a "Leyden vial"); a connection between the earth and the line wire is established at each end of the circuit by means of a thin covered wire of german silver.

1852.

Latimer Clark noted the phenomenon of the slow transmission of currents through submerged wires.—*Jour. Soc'y Arts*, April 23d, 1858, p. 356.

2885. **Whitehouse**, Dec. 12, 1853.

"In one mode of working this manipulator the depression of the key establishes a short circuit, thus draining off the current from the line wires."

2956. **Latimer Clark**, Dec. 20, 1853.

"An improvement in insulating wires used for electric telegraphs, with a view to obviate the effect of return or inductive currents."

H. V. Physick, Dec. 31, 1853.

The electrical charge assisting in long lengths of insulated wire is discharged to the earth without having to pass through the needle coil. In a reversing handle constructed with the above-described improvements a spring connected to the coil and line wire makes and breaks contact with the earth-plate before and after the transmission of the signal.

Jan. 20, 1854.

Faraday communicated the results of his inquiries respecting the Leyden jar charge of buried electric conductors to the members of the Royal Institution. He then showed that the electric currents which he employed traveled at the rate of only 750 miles per second along buried wires.

371. **C. F. Varley**, Feb. 16, 1854.

Key so arranged that when at rest a current is completed through the line wire, two of the springs being in connection with the battery poles respectively, one with the switch, and a third with the earth. On depressing the lever to transmit a signal the circuit is broken, an earth connection with the line wire made to discharge any residual electricity, and the current reversed.

"Peculiarly adapted to submarine or subterranean wires of great length."

1225. **E. O. W. Whitehouse**, June 2, 1854.

"The induced or earth current in subterranean and submarine line wires is neutralized or dispersed in three ways, viz.:

1st. By alternating currents.

2d. By an adjusted amount of conduction to earth.

3d. By short-circuiting the current in order to divert it from the instrument; to obtain infinitesimal earth contacts platinum wires (respectively connected with the line wire and earth plate) are welded into a glass tube containing distilled water or other fluid."

2555. C. F. Varley, Dec. 5, 1854.

Condenser made of sheets of tinfoil and alternating sheets of oiled silk. Says they enable him to work to very great distances through submarine cables, subterranean wires, etc.

1318. C. F. Varley, June 9, 1855.

Invention consists of improvements whereby the speed of transmission is increased, and the distance of correct communication is extended, especially in the case of very extended submarine lines. "The key used for working by means of the patentee's, translates into the Morse system." In this key, when in a state of rest, the line wire circuit is completed through a relay by means of a tail-piece to the key lever which rests on a stop, the metal key lever being connected to the line wire and the stop to the relay, a small contact lever is pointed (by spring checks) on to the fore part of the key lever, and acts against stops, by which means, when the key is depressed, it puts the line wire into circuit with the most intense of two batteries, each of which are in connection with the earth. On the rising of the key the circuit of the larger battery is broken, the smaller battery sends an opposite current through the line wire, and finally the line wire circuit is completed through the relay.

When the key lever is quite depressed, and the line wire is being charged by the larger battery to signal at the distant station, the tail of the key lever comes in contact with one terminal of a resistance coil, the other end of which is in connection with the earth. This coil consists of a great length of fine iron wire, offering great resistance to the passage of electricity, and is employed to equalize the amount of charge which the wire received for different durations of the time of contact in making "dots and dashes."

The following difficulties are obviated by the use of the improved translators. The shortening of the short marks or "dots" made by a marking telegraph by repeated translation; this effect occurs in consequence of the time required to magnetize the electro-magnets and to move the armatures, it is also owing (in the case of submarine telegraphs) to the wire not being fully charged by the momentary depression of the finger-key at the transmitting station.

The lengthening of the long marks or dashes in submarine telegraphs, the first dash may give so great a Leyden jar charge to the wire, that its effect may not subside during some few subsequent contacts at the transmitting station, and thus makes a dash and a series of dots appear at the receiving station as one long dash.

The discharge of the Leyden jar charge (in the case of submarine telegraphs) by and through the relays; this may either take place through the receiving relay after a signal has been given and the line wire circuit is connected with the said relay, thus inducing so much permanent magnetism in its electro-magnets "as to derange it from printing with the weak currents from the distant station," or (in the case of a "translator" placed between two submarine circuits) from the second circuit to the first and from the first to the second, and so on alternately (through the respective relays), until the exhaustion of the batteries.

"When a signal was made at one end a current would be translated "into the second circuit, and when the battery contact was broken at "this end the translators would also break contact with the battery it "it had put on to the second circuit. This second circuit having become "charged like a Leyden jar, would discharge itself through its relay, "and so translate back a current to the first station. The first circuit "would now become charged, and as soon as the second circuit had "become discharged, the charge of the first circuit, by returning "through the relay, would translate back again a current through the "second circuit.

"Long submarine circuits, submarine cables of the usual dimensions, "200 or 300 miles in length. The length of time required to charge and "discharge, in consequence of the very great resistance offered by the "wire, is such that to communicate at a commercial speed it is necessary "to measure out the electricity in such a way that the intensity of the "charge shall not be greater with a long contact than with a short one. "This can be effected by the induction plates of my patent, dated Dec. "5, 1854."

Figure 34 of patent is an arrangement for effecting this purpose, and is represented as applied to a Morse machine for translation.

The line wire is first disconnected from its relay; secondly, it is connected to the primary coil; thirdly, both the line wire and primary coil are put in contact with battery when the electric current divides, a large portion going around the primary coil, the remainder through the secondary coil to line

"The circulation of the current round the primary coil induces a very "powerful but momentary current in the secondary, which gives a "charge or tone to the wire.

"The primary and secondary are made adjustable. When the signal "is completed, and the lever begins to rise, the battery contact is "broken. The consequent cessation of the current round the primary "coil causes a powerful current to circulate through the secondary coil "in the opposite direction, discharging the wire."

1855.

Mr. E. O. W. Whitehouse showed the effect of oppositely charging a submarine telegraph conductor in neutralizing the Leyden jar charge. —*British Association Report for* 1885.

2089. **Werner Siemens**, Sept. 15, 1855.

Object of invention is to obviate the effect of the static or residual charge on long lines of submarine or subterranean telegraphs; consists of using a set of two insulated wires placed in close proximity to each other in the same insulated coating without using the earth as part of the circuit.

2103. C. T. and E. B. **Bright**, Sept. 17, 1855.

Magnetic regulators adjustable at various distances from the needles increase the sensitiveness of the needles, and protect them from the effect of return currents. In using very powerful secondary currents an arrangement is adopted to protect the receiving coils from the effects of the return currents.

A (magnetic) arm connected with the line wire is free to vibrate between two stops, one connected with the coil terminal of the receiving instrument, the other with that of a supplementary coil and with the sending instrument. The normal position of the arm is in contact with the terminal of the receiving coil. The supplementary coil is so connected with the sending and receiving apparatus (with the receiving apparatus through the earth circuit) that the arm is not deflected by the action of the coil, when the first current traverses the line wire; the return current, however, deflects the arm, so that the supplementary coil is then in circuit, and discharges the return current. This last discharge replaces the arm in its normal position. Thus the receiving coils cannot be in connection with the line after any current has been sent, until the line has discharged itself by passing through the supplementary coil.

1726. E. O. W. **Whitehouse**, July 21. 1856.

Employs one insulated wire as a return wire in lieu of earth circuit.

—— C. F. **Varley**, Dec. 24, 1856.

Improvement in induction coils, also key arrangement in connection with the same.

In one arrangement the currents induced in the secondary coil, both by the breaking and by the making of the primary circuit, are turned in one direction, thus sending two currents in the same direction along the line wire by the depression of the key, and two currents in the opposite direction during the rising of the key to its normal position.

To enable the currents to be transmitted in the above described manner, the key lever and its tail, respectively, make contacts with studs in contact with the other pole. A commutator arrangement, or an arm projecting vertically from the key lever, enables both the secondary currents to be transmitted in the same direction along the line wire. In another form of key adapted for long submarine circuits, a handle or winch is placed on the axis of a contact making a cam wheel, and of a commutator arrrangement similar in principle to that of the first key.

A key for working with a primary coil only. A key lever and its tail (connected to the line wire) is so mounted, in connection with springs and studs that on being depressed it breaks contact with the relay, then makes contact with one terminal of a primary coil whose other terminal is connected to the earth, then with a battery pole as well as to the coil, the remaining battery pole being in connection with the earth. On rising to its normal position, the battery contact is first broken, thus allowing a momentary induced current from the coil "to flow through the line in the opposite direction to the original current."

The action during the depression of the key is, therefore, to send a divided primary current along the line wire, and during the rising of the key to discharge the line wire from the effect of induction. The same general arrangement may be used for translation.

The key with only the primary coil, "is of great use for submarine lines, "for, on the first moment of making contact, the coil opposes a greater "resistance to the current while it is being magnetized than when it is "charged, consequently the current flowing down the line is more "intense at the first moment than afterwards. This neutralizes, to a "considerable extent, the effect of induction in the line wire, while the "reverse current discharges the line. For overground wires, working "with Morse or other relays, a beneficial effect is experienced, enabling "the communication to be carried on more rapidly. I use the same "general arrangement for translation."

211. **Pier Alberto Balestrini**, Jan. 28, 1857.

Winding around the centre core of submarine cables on which the insulated wires are laid, a thin copper wire in long, open spirals, in order to carry off the induced electricity from the insulating material.

Edward Highton, Jan. 26, 1857.

Invention consists in using an additional battery to neutralize the influence of the line current on the instrument at the sending station. The neutralizing current from the additional or counteracting battery, is brought into action by a short circuit made at the same time as the line circuit is completed, in the opposite direction, and only including the coils of the sending instrument. According to this arrangement "there is no necessity for a separate counteracting coil wire (as usually employed), and each counteracting battery adds to the power of the effects produced by the main battery on the distant coil.

329. **Sir Wm. Thomson**, Feb. 20, 1858.—Sec. 15th.

In working through a telegraph line of considerable resistance, in both directions at once, to avoid the consequent violent action of the receiving instrument at the transmitting end, by transmitting signals from that end through it, the said receiving instrument is thrown out of circuit "during certain parts of the time during which a signal is being transmitted from that end." The time during which the signal is transmitted is regulated by the arrangement of cams and springs of the key. The time during which the receiving instrument is thrown out of circuit is regulated by a separate wheel on the same arbor with proper cams.

2180. **C. W. Siemens**, Sept. 30, 1858.

Avoiding the Leyden jar charge to a wire by allowing the Morse instruments to mark signals by dots only, instead of by dots and strokes. At a second row of dots the charge of the wire is discharged. A machine is used similar to that described in 2366 of 1854.

Eng. Prov. Pat.
2250. JNO. TATLOCK, Oct. 9, 1858.
In order to obviate the influences produced by the action of the Leyden jar charge in submarine and underground telegraph conductors, the conductor is made altogether of metal, instead of employing the earth circuit for half the conductor. The two wires which respectively conduct the forward and return current are separately enclosed in and surrounded with gutta-percha.

Eng. Pat.
2515. Communicated to R. BROOMAN, Nov. 9, 1858.
So arranging of the battery force that electric currents can be transmitted to any required distance without limitations, by the action of counter currents when the circuit is broken, the said counter currents being the effects of the Leyden jar charge of a long or subaqueous conductor. The battery is divided into two or more groups, one of which is at all times in perfect circuit, but without sufficient power to affect the receiving instrument. The circuit is continuity preserving.

181. LATIMER CLARK, and JNO. MUIRHEAD, Jan. 20, 1859.—Part 4.
A galvanometer that is wound with a long coil of fine wire, has its terminals connected respectively with those of a galvanic battery and with the ends of a short auxiliary coil of fine wire, thus providing two circuits for the electric current; as the relative proportion of the two quantities always remains constant, a measure of the whole quantity is obtained. The auxiliary coil is useful for reducing the strength of the return current in submarine cables.

607. WM. CLARK, March 8, 1859.—Communication from A. H. S. Treve.
To obviate some of the Leyden jar effects in submarine cables.

465. SIR C. T. BRIGHT, Feb. 20, 1860.
Return current may be discharged between the separate signals.
A key combined with a switch is employed, by which the conductor may be cleared of the residual effects of a former current, and the circuit changed for receiving, at one operation.

1209. C. M GUILLSMIN, May 16, 1860.
Leyden jar charge of a long submarine conductor is not avoided, but is prevented from discharging itself between each signal, etc.

2047. THOMSON and JENKIN, Aug. 25, 1860.
The transmitting end of the line during the pause separating any two letters, words or sentences, is connected with a third source of electricity, at a potential intermediate between those potentials used in connection with the first and second contacts.

2116. C. W. HARRISON, Sept. 1, 1860.
A mode of dissipating the residual or Leyden jar charge of submarine conductors. Use of primary and secondary coils.

3453. C. F. VARLEY. Dec. 26, 1862.
1st. For working long submarine lines certain arrangements of induction plates with or without resistance coils, or induction coils at the transmitting end, are described and shown.
2d. Employing a "test" circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself.
This invention can be applied to almost if not all of the existing telegraph apparatus, viz.: It can be applied to the relay, or to the signaling instrument direct where no relay is used, as is the case with the needle telegraph, Thomson's reflecting galvanometer, Dignee's ink writer.

Another part of my invention consists in the employment of what I term a test circuit, formed by induction plates and resistance coils, so adjusted to each other as to produce an artificial line, possessing the same amount of retardation as the cable itself at the signaling end. In some cases, however, it may be advisable to connect the cable to the earth through an induction coil, consisting of a large bundle of iron wire surrounded by a long length of fine wire, the action of which is as follows:

On reversing the battery connections, the induction plates and battery combined send a short impulse into the cable, which divides one portion into the cable, the other through the induction coil to earth. At the first moment the iron of the induction coil offers resistance to the passage of the current, consequently, during the first instant of time nearly the whole force of the current is applied to the cable. As the iron becomes magnetized to its maximum this opposition ceases, but the plates have become charged in the opposite direction, and there is no longer any current passing from them into the cable to maintain the magnetization of the wire, the demagnetization of which induces a current in the coil and discharges the cable. In this way each impulse is followed by a short impulse in the opposite direction. By connecting the two armatures of the induction plates with a set of resistance coils, this reversal of the current is followed by a weak reversal in the same direction as the original current. The induction coil is represented as wound with two wires.

2217. Richard Laming, Aug. 29, 1865.

The suppression, either wholly or in part, of retarding charges on the signaling conductors of electrical telegraphs, by means of a second conductor placed for that purpose around each of them, and made to act indirectly upon it by possession of a permanent electrical charge of the same character as that in use for supplying the signal.

2015 W. S. Andrews, July 9, 1867.

In another part of this invention (in cases where intermediate relays are not employed to discharge underground or submarine circuits, or to neutralize at the termini the current of discharge) the contact-maker of the Hughes typewriter is prolonged by a separate piece working on the same vertical shaft, which, by an arrangement of connections, affects the required discharge. In sending neutralizing currents, an insulated disc, on the vertical shaft of the contact maker, is in contact with a spring from the neutralizing battery.

2875. Chas. T. Bright, Oct. 4, 1869.

At the sending end a key is employed, in which the line wire is placed to earth during the intervals between the signals. A greater resistance than is used at the receiving end is inserted when a signal is made.

1044. C. T. Varley, April 8, 1870.

Dr. Gintl and Frischens' double speaking apparatus and a hollow helix may be connected between the receiver and the line wire, the helix having pieces of iron inserted into it to remove the difficulty arising from the inductive capacity of the line. Helix to be of No. 26 silk-covered wire, 10 inches long, 1¼ inches diameter inside, 4 inches diameter outside. Small iron rods are placed in the helix.

1094. Edw. Bull, April 25, 1871. (Void.)

To prevent the current of the translator on the down line from passing through the coils of the translator on the up line. Condensers are used on cable circuits between the end of the line of each particular section and the earth.

2286. Geo. Little, Aug. 30, 1871.

2d. The transmitting instrument is connected with the main line and with the earth. In the line leading to earth is one battery, the other battery is in a circuit united to the earth circuit at one side of the instrument and to the main line at the other side. The negative of one battery is connected with the negative of the other. When the transmitting current is interrupted a reverse current is brought into action to clear the line, etc.

1207. **Geo. Little**, April 22, 1872.
In submarine circuits the transmitter draws from a condenser at a distant station.

3344. **J. B. Stearns**, Nov. 11, 1872.
In working submarine lines a condenser is placed between the relay and the resistance coil, one part of its metallic sheets being in connection with the earth.

3701. **Geo. K. Winter**, Dec 6, 1872.
To obtain a high speed on long circuits.—Induction coil, etc.

761. Geo. K. Winter, March 1, 1873.
In duplex working. The static induction of the cable is counteracted by magneto-electric, or by battery induction. The induction may be initiated in a local circuit.

861. **Wm. C. Barney**, March 10, 1873.
To prevent the tailings which sometimes occur in electro-chemical telegraphs, the positive current (or that which acts on the recording paper) is sent from the transmitter to the earth plate direct.

1508. **T. A. Edison**, April 25, 1873.
To enable perfect signals to be transmitted and received in cables and long telegraph lines, an artificial line is placed on the opposite side of the receiving instrument to the cable. The receiving instrument is thus interposed at the point of no electric tension. The artificial line has the same resistance and capacity for providing static charges as that of the cable.

Between the receiving instrument and the earth one or more condensers or other accumulators of static electricity are interposed.

2870. **J. B. Stearns**, Sept. 1, 1873.
It is a well-known fact in telegraphy that a submarine or subterranean telegraph wire cable or line, and in a lesser degree, also, a land line or suspended telegraph wire or line, as used in the transmission of signals, is not only a conductor of electricity, but is also a reservoir of electricity, in the sense that a Leyden jar is a reservoir.

In the system known as duplex telegraphy, this charge and discharge become troublesome, and condensers, and also induction coils, have been employed to obviate their effect upon the receiving instrument, as described in specification of Nov. 11, 1872. To render the charges equal a portion of the artificial line is included between the instrument and the condenser. Instead of the condenser, an induction coil may be used, or the instantaneous current from the sending battery, or a signaling battery.

3879. **J. B. Stearns**, Nov. 27, 1873.
The condenser may be in the form of a submarine cable having great resistance and capacity to neutralize the effect of the static charge returned from the cable; mechanical, hydraulic or pneumatic means may be used in the receiving instrument. The static balance may be effected independently of the magnetic compensation; in this case the condenser may be of small capacity. The receiving wire of a differential receiving instrument may be used as a bridge wire of a duplex bridge, in connection with a condenser or induction coil, charged and discharged through the other wire; or the receiving instrument may be wound with three wires, two used in the ordinary (differential) duplex working, the static compensation being effected by means of the third wire. Instead of the third wire a separate compensating means may be employed.

439. **Henry Highton**, Feb. 3, 1874.
The object of this invention is to obviate retardation in submarine cables.

At either end, or at each end of the line, also at an intermediate point thereof, an arrangement of pairs of plates is placed. The pairs are of metal or carbon, arranged as a galvanic battery, except that the plates of each pair are similar, and only one conducting liquid is used.

The electrical effect of this is similar to the mechanical effect of a spring in machinery, and immediately the electrical impulse ceases, the original electrical condition of the line is restored by the reaction of the plates, so as to be ready to receive a fresh impulse.

822. **C. Leman**, March 6, 1874.
A neutralizing current is sent between signaling currents.

1966. **J. W. Brown**, June 5, 1874.
When transmitting a dash to the receiver, a strong current is sent, then an earth contact is made through the compensation pen, then a second strong current, and finally a reversed current. Permanent leak and magnetic shunt are shown, to obviate running the dashes and dots together, and to increase the speed.

2539. **Foote and Randall**, July 20, 1874.
To prevent tailings in an automatic telegraph two currents of opposite polarity are used, one for marking, the other for clearing the line.

4063. **W. E. Sawyer**, Nov. 26, 1874.
In an automatic telegraph a variety of devices are show to clear the line of tailings. At the cessation of an impulse, a perfect ground contact is made at the transmitting station Induction coils and equating batteries are included.

684. **A. Muirhead** and **H. A. Taylor**, Feb. 24. 1875.
Improvement in the arrangement of a condenser for artificial lines of a duplex.

2351. **W. E. Sawyer**, June [illegible]8, 1875.
Battery, induction coils and resistance are introduced in the line at the receiving end to prevent the effect of tailings.

3374. **John Muirhead**, Jr., Sept. 27, 1875.
Eliminating disturbances or kicks that take place on receiving instruments in duplex working, by connecting up so the instrument is not immediately in connection with a circuit of high capacity. Increasing the capacity of the instrument, and arranging the sides of the bridge so as to have capacity to receive a charge; introducing a condenser of small capacity, with variable resistance, at a suitable point in the artificial circuit; placing the primary wire of an induction coil (in connection with the extremity of the bridge at one end) to earth, and to make its secondary coil a shunt to the recorder.

47. **Benj. Smith**, Jan. 5, 1876.
To prevent the "kick" an adjustable resistance is inserted at the termini of the cable, between the Wheatstone bridge, or other differential arrangement, and the artificial line.

2541. **Wm. Dickenson**, June 19, 1876.
Grounds the line when making a signal, causing a partial discharge of the line.

2564. **A. and J. Muirhead**, June 21, 1875.
To make the cable and artificial line of a duplex similar, condensers, induction coil and resistances are variously disposed.

2941. **J. W. Brown**, July 19, 1876.
To increase the speed of recording dots and dashes, employs positive

and negative currents, which are transmitted through two rows of perforations in a paper strip, also making an earth contact.

American Patents.

125582. G. Little, April 9, 1872.
A condenser in combination with electro-magnets, a rheostat and constant current.

126847. J. B. Stearns, May 14, 1872.
In a telegraph apparatus for double transmission, the combination with the relay at each station of a condenser for the purpose of neutralizing the effect of the return current due to the static induction of the line.

134867. T. A. Edison, June 14, 1873.
Neutralizing any earth or extra currents in automatic instruments, by a weak constant local current, preventing tailings and blurs in the writing.

135531. T. A. Edison, Feb. 4, 1873.
Reversed induced currents from electro-magnets in branch circuits, neutralizes residual or extra current in main line, and thus avoids blurs or tailings.

136873. J. B. Stearns, March 18, 1873,
Electro-magnets are arranged in a branch circuit from the equalizing magnet circuit, the extra currents therefrom neutralizing the static induction upon the receiving relay.

136876. J. B. Stearns, March 18, 1873.
A shunt circuit is established around relay by action of its own armature lever, or by the lever of the sounder it controls, thus lessening retardations and ensuring decisive action.

141772. T. A. Edison, Aug. 12, 1873.
Part of main current shunted through branch circuit. Effect of extra line current neutralized by an extra current from a local battery regulated by a rheostat.

141773. T. A. Edison, Aug. 12, 1873.
Line kept statically charged by the main battery, whose circuit is made and broken with immense rapidity by a pulsator resistance, being such that these currents do not affect receiver; transmitter in shunt around the resistance. Receiver has two or more pens in circuits having shunts containing magnets of varying size.

141776. T. A. Edison, Aug. 12, 1873.
The use of an opposition or secondary battery of weak power, at one or more points, to act in the main line in opposition to the pulsations from the transmitting instrument, to free the line of surplus or static electricity.

142486. G. Little, Sept. 2, 1873.
Condenser or coil applied in a branch circuit to electro-magnet to neutralize effect of induced current.

147311. T. A. Edison, Feb. 10, 1874.
States that the static charge of a line proceeds in both directions from the centre of the resistance of the line, and that at such centre the tension of the static or extra charge is zero, and that if the receiving instrument be placed at that point there will be no tailings; and introduces an artificial line between the receiving instrument and the earth, to balance the resistance and static charge.

147313. Thos. A. Edison, Feb. 10, 1874.
Instead of a single electro-magnet in a shunt circuit to the receiving and transmitting instruments, as in his patent No. 135,531, a number

are employed, with a switch for throwing more or less into circuit, as in the case of the ordinary rheostat; also uses a rheostat in connection with the series of magnets.

153064. FOOTE and RANDALL, July 14, 1874.

In an automatic or chemical telegraph, the method of obviating tailings or blurs, and of effecting a ready discharge or freeing of the line, the same consisting of throwing upon the line, immediately upon each and every break in the circuit of the recording current, a current of opposite polarity.

In the *Telegrapher* (July 25, 1874), page 179, we find the following, over the signature of Geo. H. Grace.

> "TO THE EDITOR OF THE NEW YORK TRIBUNE:
>
> "As to the assertion that it is undisputed that Mr. Edison is the inventor of the device for neutralizing the after current, I have only to state that it is well known that Mr. Edison's claim to that invention is and always has been, disputed by me. I used the magnets at each end of the line for the purpose described, long before Mr Edison had anything to do with automatic telegraphy."

154479. C. H. HASKINS, Aug. 25, 1874.

Condenser in branch circuit, connected directly with main line circuit, so that extra charges from line and from condenser pass over the same wire in opposite directions.

157469. G. D'INFREVILLE, Dec. 8, 1874.

A sounder is utilized in a shunt circuit to counteract the static charge and discharge of the line wire.

158412. WM. E. SAWYER, Jan. 5, 1875.

A combination is made of a line, its battery and contact point of an induction coil connecting the line to earth, and throwing the secondary induced current into the line for the purpose of clearing the same of tailings.

160581. M. G. FARMER, March 9, 1875.

Claims that when the circuit of a duplex apparatus is closed, the static charge in the line causes the coil in the main circuit to momentarily affect the armature before the equating coil acts thereon, and introduces an inductorium, the primary coil of which is in a local circuit, the secondary coil being placed in either the line or equating circuit, so that when the sending key is operated the secondary currents will oppose the effect of the line charge and discharge.

165620. WM. E. SAWYER, July 13, 1875.

Throws into line battery currents of one polarity and an electro-magnetic induction apparatus, so arranged as to throw into the line currents of opposite polarity to the battery currents.

168243. T. A. EDISON, Sept. 28, 1875.

A signaling electro magnet is placed in the line with a secondary battery, and a shunt is placed around the instrument.

168385. T. A. EDISON, Oct. 5, 1875.[1]

Places an electro magnet in each arm of the bridge of a bridge duplex, and also establishes a supplementary artificial circuit, in which is also placed an electro-magnet, the extra currents of which are intended to neutralize the static charge and discharge of the line. This invention is disclaimed by Mr. Edison on November 19th, 1878, on the ground that it is set forth in a previous application dated Sept. 1st, 1874.

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[1] On referring to the files for Sept. 1st, 1874, we find that Edison filed a caveat for the following arrangements for meeting static difficulties in both bridge and differential duplex systems. 1st. Subdividing the condenser and resistance coils in the artificial equating circuit to more nearly coincide with the line wire or cable in the time of charge and discharge. 2d. The arrangement of a subdivided artificial line, with a cable or land wire worked by induction from condensers. 3d. The introduction of an electro-magnet in a shunt around the coil of the relay in the artificial circuit. 4th. An electro-magnet is placed in the line circuit, between the dividing point and the coil of the differential relay; also, in the arm of a bridge duplex on the artificial side. 5th. A secondary battery is placed directly in the artificial circuit, between the relay and the compensating resistance. 6th. To obviate the detrimental effects of the discharge from relay magnets, inserted by mistake in the line and way stations, an electro-magnet is inserted in the artificial circuit, at such a point as will allow its charge and discharge to balance the one in the line. 7th. The primary coil of an inductorium is inserted in the artificial circuit, between the relay and the earth, and the secondary coil is connected to an extra electro-magnet, which acts on the relay armature in opposition to the line relay electro-magnet, so that it tends to counteract the effect of the static charge and discharge of the line.

178223. T. A. Edison, May 30, 1876.

Shows a mechanical compensator, consisting of a flat spring attached to the armature lever of a differential relay, and a notch lever operated by a local circuit. The notch lever engages with the spring to mechanically neutralize the effect of the static charge and discharge of the line.

190898. Geo. B. Prescott, May 15, 1877.

To prevent the signals being shattered on the neutral relay in a quadruplex telegraph when reversals of current are used, an electro magnet is so located as to pull on the armature of the neutral relay in the same direction as the line magnets. This auxiliary electro-magnet is connected up in a condenser shunt around a rheostat in the bridge, so that the received currents give momentary energy to it through the charge and discharge of the condenser.

196833. W. E. Sawyer, Nov. 6, 1877.

A regulator periodically put the line to earth or to a discharging battery, for effecting the static discharge of the line.

207724. T. A. Edison, Sept. 3, 1878.

In a quadruplex the artificial line is provided with two or more condensers of varying capacity, and a like number of rheostats of varying resistance, for regulating the charge and discharge of the same to correspond with that of the line.

An auxiliary electro-magnet is placed opposite the electro-magnets of the neutral relay, to act in conjunction with the retractile spring. A polarized relay, included in the bridge wire, operates this auxiliary electro-magnet in a local circuit, through either its front or back stop, so that during reversals of the received current, the local circuit is momentarily broken and the false signal avoided.

201374. Charles H. Wilson, March 19, 1878.

The detrimental effects of induced currents between lateral line wires are neutralized upon single wires by the interposing condensers and induction coils between them; and upon duplex and quadruplex wires by interposing condensers, resistance and retarding coils between the artificial circuits, and making their discharge equivalent to that of the line.[2]

209241. T. A. Edison, Oct. 22, 1878.

The drawing shows a bridge quadruplex system, in the cross wire of which a polarized relay, neutral relay, and a rheostat are included. Around the rheostat is placed a condenser, which, like the relays, is only affected by the received currents, and acts upon the neutral relay, so as to steady its signals during reversals.

217304. Benjamin Thompson and Charles Selden, July 8, 1879.

A condenser is arranged to form a shunt around the duplex relay coil situated in the line circuit.

225140. F. W. Jones, March 2, 1880.

A condenser is arranged to be charged by a separate battery, and to be discharged directly into the line through a system of duplex, employing single coil relays. This only obviates the effect of the discharge of the line wire.

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[2] In the "Journal of the Society of Telegraph Engineers" for 1879, Professor D. E. Hughes has a very instructive paper on the effects of induction between lateral wires. W. H. Preece, Professor Bell, and others, have also made valuable contributions on the same subject, which has been dealt with more particularly with reference to the telephone. As many patents have been obtained, both here and abroad, for shielding that most delicate instrument—the telephone—from induction effects, I will leave this very extensive branch of the subject to others more conversant with it, for elucidation.—F. W. J.

238912. F. W. Jones, March 15, 1880.

A shunt of double-wound resistance, to obviate the effects of extra currents in a telephone circuit.

230802. Alexander Muirhead, Aug. 3, 1880.

A method of adjusting artificial lines or compensating circuits in systems of duplex and multiplex telegraphy; which consists in inserting an adjustable leakage circuit in the artificial line, and varying its positive to closely imitate the conditions of the line wire. This improvement was patented in England Feb. 24, 1875.

231904. J. E. Fenn, Sept. 7, 1880.—Also,

236321. J. E. Fenn, Jan. 4, 1881.

An adjustable electro-magnet is placed in the line next to the receiving instrument, to neutralize the static discharge of the line.

234347. T. F. Taylor and Gerritt Smith, Nov. 9, 1880.

A condenser is placed in a shunt between the line and earth at the sending station, for the purpose of prolonging the duration of the outgoing currents.

237595. Chas. A. Randall, Feb. 8, 1881.

A device for sending alternate impulses to line, and thus free it of tailings.

238094. George D'Infreville Feb. 22, 1881.

The capacities of the main and artificial lines are made equal at the instant of transmitting a signal, by automatically diminishing the resistance in the artificial circuit for an instant only, and then restoring it to its normal condition.

238399. F. W. Jones, March 1, 1881.

A shunt is placed around an electro-magnet, to prevent its extra currents from destroying the voice waves of telephonic communication.

238448. Gerritt Smith, March 1, 1881.

A device for killing the static discharge. One pole of a condenser is attached to the main line and the other to a supplementary artificial line, which passes to ground through the coils of the home relay, thus permitting the re-acting discharge of the condenser to neutralize that of the main line.

244218. S. D. Field, July 1, 1881.

To avoid the difficulty of the static charge and discharge of a line on a duplex. the receiving instrument is short circuited, and the bridge wire (in which said receiving instrument is located) is broken for an instant, both on the opening and closing of the home key.

253154. C. L. Buckingham, Jan. 31, 1882.

To avoid troubles due to static charge and discharge in a duplex, a normally closed bridge unites the artificial and main lines at points beyond the differential receiving instrument, and the static charge and discharge are caused to act equally upon both coils of the receiver, by reason of the bridge. This bridge is broken by a signal from the distant station.

257499. J. W. Larish, May 9, 1882.

In a duplex an electro-magnetic shunt is provided around the artificial line coil for avoiding the static difficulties, and the battery is momentarily connected through the home relay at the instant its connection with the main line is broken, for preventing false signals due to extra current charge.

258366. C. L. Bukkingham, May 23, 1882.

An arrangement for rendering the receiving relay of a differential duplex system insensible to the effects of the inductive charge and discharge of the line, by causing both inductive charge and discharge, respectively, to be divided through the two oppositely wound coils of the differential relay.

258367. C. L. Buckingham, May 23, 1882.
Introduces in the line and artificial circuit, an extra differential relay, whose lever and back stop forms a bridge conductor, between the main and artificial line next to the main line, and at points of equal potential of the outgoing current.

258428. F. W. Jones, May 23, 1882.
In a duplex a branch line, including an electro-magnetic inductor, extends from a point between the main line and the receiving instrument to earth.

253636. J. E. Fenn, May 30, 1882.
To prevent false signals upon the receiving instrument of the home station, caused by the extra current set up by the receiving instruments of a distant station, the artificial circuit is provided with electro-magnetic induction apparatus, interspersed with the equating resistance, so as to imitate in the artificial circuit the effects of the distant extra currents coming over the main line through the relay.

258957. B. Thompson and C. Selden, June 6, 1882.
A condenser is placed in the artificial line, between the transmitter and the receiving instrument, and so arranged as to utilize the charge and discharge of both faces in overcoming static disturbances.

259106. Dillon and Brown, June 6, 1882.
In a system of tension duplex a device for overcoming the static discharge, by sending the secondary current of an induction coil through one coil of a double-wound relay—the primary coil of inductorium being in the local circuit of transmitter.

260208. F. W. Jones, June 27, 1882.
In a tension or two relay duplex an artificial current is formed around the relay nearest the line in the same direction as the line circuit. An electro-magnetic induction is included in the artificial circuit, and opposes, by its extra current, the effects of the line static.

261916 S. D. Field, Aug. 1, 1882.
To avoid the effects of the static charge and discharge in a duplex, an electro-magnet, having a closed magnetic circuit, is placed in the main line near the receiver, and provided with a permanent magnet for adjustment with relation to the cores of the magnet, and a normally open shunt around the inductor, and a device actuated by the transmitter to close the shunt at the instant the current is set to or taken from the line.

268317. Benj. Thompson, Nov. 28, 1882.
The poles of a condenser are connected to the main and artificial lines respectively at points of different potential.

280703. A. Muirhead, July 3, 1883.
The potential of the battery applied to the artificial line of a duplex is modified by an electro-magnetic shunt, a separate battery being used for signaling on the line.

828667. B. Thompson, Oct. 16, 1883.
In a duplex a short circuit is completed around the sounder at the instant of the flow of the static charge and discharge.

291318. S. D. Field, Jan 1, 1884.
In a duplex an electro-magnetic inductor is placed in the line circuit, and a shunt connecting the line with the transmitter is established around the line coil of the relay and the inductor.

291096.
291097. } C. Selden, Jan. 1, 1884.

A local auxiliary neutralizing coil and a condenser are so connected to the relay and transmitter of a duplex as to be brought into action in opposition to the static discharge at the moment of its discharge.

293110. T. F. Taylor, Feb. 5, 1884.

An opposing battery, having less electromotive force than the transmitting battery, is placed in the line at the receiving station.

300781. F. W. Jones, June 24, 1884.

A static compensator or inductorium has one coil included in the main line circuit and the other coil in a supplementary convolution of the receiving instrument, so that secondary currents of the secondary coil are reverse to the static charge and discharge of the line.

304106. F. W. Jones, Aug. 26, 1884.

Duplex or quadruplex relays with three coils are employed, two of which are connected up as usual for the line and artificial circuit. A second artificial circuit, starting from the dividing point next to the transmitters, goes around the third coil of the relays to earth in the same direction as the line coil. In the second artificial circuit are rheostats and electro-magnetic inductors, so graduated as to generate extra currents equal and opposite to the static charge and discharge of the line.

309571.
309572. } C. Selden, Dec. 23, 1884.

An auxiliary electro magnet in a local circuit is arranged to exert its force on the armature of the line electro-magnet in opposition to the coils of the relay. The transmitter momentarily closes a local battery around the auxiliary coils at the instant the discharge line discharges. Also an ingenious arrangement of polarized sounder, reversing relay, battery and local circuit, so as to withdraw the local current from the sounder at the instant of opening or closing the sending key.

313787. H Van Hoevenbergh, May 10, 1885.

In a quadruplex telegraph a method of preventing false signals upon the receiving instrument, controlled by the armature of the neutral relay upon the reversal of the main line current, which consists in momentarily neutralizing the local current, actuating said receiving instrument by means of an opposing electromotive force.

319428. Gerritt Smith, June 2, 1885.

In a quadruplex telegraph system, in which reversals of current are employed for the transmission of one set of signals, a neutral relay provided with two coils, one of which is embraced in the main line and the other in a branch, which includes a condenser, and is connected with the main line between the neutral relay and the earth and with the earth.

310684. F. W. Jones, 13, 1885.

A static compensator for duplex and multiplex telegraphs, consisting of an inductorium, one coil of which is in circuit between the main line and the point of division of the main and artificial lines, or beyond the point of division of the main and artificial lines; while the other is in a closed circuit, including means for counteracting the effects of the static charge and discharge current upon the receiving opposite.

320987.
321404.
322333.
323239. } F. Van Rysselberghe, June 30, 1885.—July 28, 1885.

The method of rendering telephonic or other electric currents—whether primary, induced or derived—inaudible in telephones, consisting in rendering gradual the emission and extinction of the telegraphic or other electric currents, by the introduction of an electro-magnet in the circuits; also by the attachment of condensers.

322692. P. B. **Delany**, July 21, 1885.
The combination of a main line synchronously actuated apparatus connected with each end of the main line, a table of contacts and a rotating circuit, complete at each end of the line, which traverses over the table of contacts and successively places the main line in connection with each of said contacts. Static discharge contacts arranged between the first-named contacts, and connected together and to earth, and a resistance between the static discharge contacts and the ground.

322739. L. O. **McPherson**, July 21, 1885.
In a quadruplex telegraph a condenser having one pole connected with the conductor leading to the said instruments, and the other connected with the earth, whereby said condenser will receive a charge opposite to the static charge occasioned upon the main line.

327097. **Alex. Muirhead**, Sept. 29, 1885.
A supplementary condenser and rheostat are included in a shunt around the condenser in the artificial arm of the bridge.

326892. F. **Van Rysselberghe**, Sept. 22, 1885.
To prevent false signals or reversals, a relay is placed in a branch wire from the main line to a condenser, the other side of which is to earth. The local points of this relay control a battery, which actuates a supplemental or holding electro-magnet, acting upon the same armature lever as the neutral relay in the main circuit.

The **President**: Although perhaps Mr. Jones's paper is not as interesting to read to an audience as some of those which preceded it, I think those who have had occasion to do work in that line will appreciate the amount of labor he has bestowed on it, and recognize its value when incorporated in our records. Every increase in the capacity of a wire renders the elimination of these static difficulties more and more important, and as time goes on the value of a contribution of that kind will become better and better appreciated.

During our meeting last evening, a Committee was appointed to take into consideration the propriety of some action by this Institute in relation to the British Standard Wire Gauge. This wire gauge has been endorsed and recommended by the National Electric Light Association and the National Telephone Exchange Association. I do not recollect the official details of their action, but that will appear in the course of the proceedings, and the matter was referred last evening to a Committee of five, who were instructed to report if possible at the meeting to-day. I will now ask that Committee if they have any report to make.

The **Secretary**: The report is nearly ready. It is not quite in shape, but we will have it so before the meeting closes, and also the report of the other Committee on monthly meetings; so that if you will go on with the final paper on Secondary Batteries, the

Committee will be ready to report probably when the reading of that is finished.

The President: We will postpone the consideration of that until after we have read the paper. We have two more papers down on our programme, one by Mr. Bauer on Secondary Batteries for Light and Power, and the other by Mr. Byllesby on Incandescent Lighting Systems. Mr. Byllesby unfortunately has been so much occupied that he was unable to get his paper ready in time, so that we shall be deprived of the pleasure of listening to that. Mr. Bauer's paper I will ask Mr. Mailloux to read, as he is especially familiar with the subject.

SECONDARY BATTERIES FOR LIGHT AND POWER.

BY A. H. BAUER.

So much has been written of the the theory of secondary batteries, that I assume it would be more interesting to the members of this Institute to confine my remarks to a history of what has been done practically during the past three years with the Faure battery at Baltimore.

In May, 1882, a set of Faure batteries was brought from Paris by the steamer Labrador, and sent to Baltimore. This battery was composed of 60 cells, each containing ten plates, with a supposed capacity of 200 ampère hours at an E. M. F. of 2 volts. The plates were made of sheet lead, 9½″ long, 5½″ wide, and 1/16″ thick, mechanically perforated with 400 holes ⅛″ diameter. They were coated with a paste made by mixing sulphuric acid and red lead, which was held in place by wrapping the plate in felt. They were set in lead-lined boxes, with the terminals of five plates joined together with brass clamps to form the positive, and the remaining five likewise connected to form the negative poles. Twenty-four of these cells were placed on exhibition in the offices of the Electric Storage Co., and arranged to run a lot of Edison B lamps, small motors, etc. The charging machine was an Edison Z A dynamo, located about half a mile from the office.

These batteries gave satisfactory service for about six months, when they failed rapidly—first one, and then another, would refuse to store, until nearly all had become useless. Examination disclosed many causes for the failure, which at that time was imperfectly understood. One of the defects was the interposition of felt between the plates, which increased the internal resistance; and after a time the felt got rotten and fell off, causing a short circuit.

Realizing these and other defects, the matter was taken in hand with the intention of evolving a practical battery, with what results the following will show:

The first plate giving promise of success was cast in an iron mould; its dimensions were 12½″ long, 9½″ wide, and ⅜″ thick, weighing 6½ lbs. They were in the form of grids, having 480 holes ⅜″ square. These holes were filled even with the surface of the plate with 5½ lbs. of a mixture of red lead and sulphuric acid, and allowed to dry. Twelve of these plates (6 positive and 6 negative) were placed in a rectangular box lined with a mixture of pitch and asphalt. The plates were separated by pine boards 3″ thick. Forty of these cells were connected in series with an Edison 110-volt machine and charged with a current of 50 ampères for 300 hours.

From the first, several difficulties presented themselves, one of which was that the wood boards prevented a free circulation of liquid between the plates, causing the charging current to pass from one plate to another at one or two points where the resistance was least. Another was the constantly increasing resistance due to the sulphating of the copper connecting strips joining plates and cells together. The next step was the removal of the wood boards and the substitution of pine strips ¼″ square section, and 10″ long; four of these were placed between each pair of plates; the copper connectors were painted with an insulating paint.

These changes made a vast improvement in the working of the battery. A number of cells that before had persistently refused to receive or hold a charge, now became active, and could be relied upon to give a satisfactory current. While with the same plates separated by boards, the internal resistance of the cells averaged $\frac{1}{160}$″ ohm, that of the same cells with ¼″ strips fell to $\frac{1}{500}$ ohm. In the course of time, however, the copper connecting strips gave trouble. In spite of the insulating paint, the acid would attack the strips, forming sulphate, and developing a high resistance.

While much had been learned from these experiments, and some progress had been made towards a practical battery, yet it was seen that the great weight (250 lbs.) per cell of those in service must be reduced. About this time the writer visited London, for the purpose of studying the improvements made by the Electric Storage Company at Millwall. Immediately upon his return the subject was taken up anew. It was found necessary to make numerous changes. While the cast perforated plate was still used, its dimensions were reduced to 10″ long, 9½″ wide, and $\frac{3}{16}$″ thick, and its weight to 2½ lbs. These plates were pasted with 2½ lbs. of active material. The only size cell made at that time was termed an A 1 h. p. cell.

$$\frac{E \times C}{746} = El.\ h.\ p.$$

and consisted of 16 plates (8 + and 8 —) in a lead-lined box, separated by pine strips $\frac{1}{4}''$ square section.

They had a capacity of 370 ampère hours at 2 volts E. M. F.,

$$\frac{2 \times 370}{746} = 1 \; El. \, h. \, p.$$

Instead of using copper or brass rods, or strips for connecting the plates and cells together, lead was substituted. This battery showed a great improvement over the first made. It was found to be thoroughly reliable. It would retain its charge for months without practical loss. Numerous experiments were made to determine their capacity and efficiency. These tests have always been of a practical nature—two of which I will quote: 32 cells were charged with 20 ampères for 20 hours. A carefully calibrated ammeter was kept in circuit during the entire time.

To discharge, the battery was connected to two Weston arc lamps in series, and a current of 20 ampères for 16 hours was obtained before the E. M. F. fell to 1.5 volts per cell; this was equal to an efficiency of 80 per cent.

The same test was repeated, except that Edison B lamps were used for the discharge with a return of 340 ampères or 94 per cent. before the E. M. F. had fallen to 1.5 per cell.

On May 1, 1884, an installation of 3 h. p. cells for supplying 255 16 c. p., 70-volt lamps was made at the Academy of Music, for lighting the stage. This battery is located in the cellar, each cell consists of 48 plates in lead-lined boxes and has a capacity of 1,200 ampère hours at an E. M. F. of two volts. The location is not the best for high efficiency—a well occasionally overflows, thoroughly wetting the framework on which the battery rests as also the wooden boxes themselves, causing at times, serious leakage and loss of current. Even under these adverse circumstances the battery is still in service and doing remunerative work.

The lamps used are the Weston 70 volt $\frac{8}{10}$ ampère, and comprise 98 footlights of various colors, five borders of 20 lamps each, the balance being distributed among the dressing rooms, stage entrances, etc. Each border and the different colored footlights is on its own circuit and controlled by its own switch. An arrangement is used whereby the light can be increased or diminished from the stage by adding or subtracting any number of cells from one to 16 as desired, thus producing all the effects that heretofore had been done with gas. This battery is charged every night with two 10-light arc machines, giving a total of 50 ampères.

It is of course understood that during the time of a performance a current of about 230 ampères was required to maintain the lamps, of which the dynamos furnished 50 and the batteries the balance. As this demand was not continuous during a performance, the total time not being over four hours in 24, it is possible by running the two machines for an average of 10 hours per day to keep the battery thoroughly charged and always ready to furnish current when required. This plant has been in daily service for two years. At this writing another installation of 3 h. p. cells supplying 300 38-volt Swan lamps is being made for the Crescent Club of Baltimore, and will probably be in service within the next month.

Some work has been done with the batteries for cautery, faradic and constant current purposes. For the cautery a current of from 10 to 30 ampères is required, depending upon the length of platinum wire to be heated, and as they are in service not more than one minute at any one time—small capacities are required. These batteries are made up with plates measuring 7″ long, 5″ wide and $\frac{3}{16}$″ thick, weighing two pounds. For office practice they have a capacity of 200 ampère hours, and weigh 43 pounds; those made portable have a capacity of 25 ampère hours, and weigh eight pounds. They usually run from three to six months without recharging.

A very interesting experiment was made a short time ago with 50 secondary cells on the wires of the Western Union Telegraph Co. A wire from the battery was run to the Baltimore office to which were connected 38 Morse and three gold and stock circuits, the resistance of which varied from 50 to 6,000 ohms. At the same time three incandescent circuits consisting of 56 Maxim 25 c. p. and 24 Edison 8 c. p. lamps were also being supplied from the same battery. The number of cells of primary battery displaced was 1375 gravity and 110 carbon. The experiment was continued daily for more than one week.

Less than one year ago a battery consisting of 49 four-plate cells, having a capacity of 100 ampère hours, was taken to the Daft electric railway station near Baltimore, and placed on one of the motor cars used in that system and connected to the motor and switches in the usual way. An extra switch being used, however, to vary the E. M. F. by adding or subtracting a certain number of cells. The total weight of car, motor, batteries, etc., was about 5½ tons. Three trips of about one mile each was made.

As this experiment was made merely to show that the batteries could be used for the purpose no tests were made. Encouraged by the success of that experiment a 20-foot car weighing 5,400 pounds was borrowed from one of the Baltimore railway companies, and taken to the Viaduct Manufacturing Co.'s place, where an eighth of a mile track was laid. The following described system was devised:

It consists of two beams extending between and resting on bearings on the two car axles. These beams carry a motor, counter shaft, and gearing. The armature shaft of the motor is extended and carries six inch pinions on each end which mesh into 20″ counter gears. On the counter shaft is a six inch pinion which meshes into a 24″ gear on the front axle of the car. The motor is wound in three sections, each section is connected to the battery by a double three point switch located on the platform by which one, two, or three sections can be connected in circuit depending upon the amount of power the motor is required to develop.

In all previous experiments with batteries for power purposes the resistance of the motor was constant, the variation of power being had by adding or subtracting a certain number of cells. In the present system the number of cells in circuit is constant, and the current is varied by varying the resistance of the motor. In the former case a number of cells were exhausted, while a number were in good condition, and at the end of a certain time an irregular battery was the result. In the latter each and every cell does the same amount of work and all are discharged alike. Although the tests of the system are as yet incomplete, the following data may convey some information.

The resistance of one section of the motor plus that of the armature is .57 ohm, of two sections in multiple are .32 ohm. and of three sections .20 ohm. The counter E. M. F. is respectively 70, 90, and 100 volts at 800 revolutions of the armature. The battery gives an E. M. F. of 120 volts, the internal resistance is .06 ohm. The track is about one-eighth mile in length and commences at the foot of a 1 in 20 grade on a curve of 45 feet radius. The total weights of the different parts of the system is as follows:

Car	**5,400**	**pounds.**
Motor	**923**	**"**
60 cells battery	**5,400**	**"**
Gearing	**900**	**"**
Total	**12,623**	**pounds.**

This car has been running almost daily for the past two months, and with the exception of an accident due to the irregularity of the track causing a run off when coming down grade on the first trip, no trouble has occurred, and no changes or alterations have been found necessary. Sixty cells of battery of a total weight of 2,580 pounds are now being tried. The large size gives a continuous run of 36 miles. It is expected that the smaller should be able to propel the car 18 miles.

As before stated the tests are very incomplete, and I regret I am not able to give you data sufficient to judge of the merits of the system.

There are many experiments that we were obliged to make in order to become thoroughly acquainted with the battery, and which it would only take up your valuable time to mention. I will, therefore, merely add a few words in regard to certain erroneous ideas that have been held by a large number of people respecting batteries in general and storage batteries in particular.

When the announcement was first made of the great discovery by Camille Faure, it was also said that the secondary battery was a simple contrivance composed of lead and sulphuric acid put together in certain proportions placed in wooden boxes, carted around the city and delivered to subscribers at stated times, that it could be placed in the cellar, vault, or some other out-of-the-way place, and without any attention whatever would always be ready to furnish current at any moment either day or night. Such ideas instilled into the minds of an unthinking public have done great injury to the battery interests. A little thought and study would have shown the fallacy of these promises.

A secondary battery requires precisely the same amount of care and attention as a dynamo or other source of electrical energy doing the same amount of work. As a matter of comparison, suppose the plant at the Baltimore Academy of Music to be run from a dynamo capable of maintaining 255 16 c. p. lamps. In addition to the dynamo a 30 h. p. engine and boiler will be required. Now, to properly take care of the installation, it will be necessary that at least one man give it his entire time and attention. At stated times the boiler will be thoroughly examined. He will probably use a compound in the feed water or take other means to remove scale. He will watch his gauges very closely to see that the proper quantity of water is in the boiler. His engine will be set perfectly level on at least a six-foot foundation, and all its moving parts closely watched to prevent an accident and stoppage. If he be attentive the engine will be kept scrupulously clean. His dynamo will receive as much if not more attention than any other member of the plant. He will use a good quality of oil in its cups and see that it feeds properly to prevent undue friction in the bearings. He will be extremely careful to prevent dirt, dust, etc., accumulating on the machine, and whenever possible he will remove the armature, clean it of dust and dirt, and give it a coat of shellac. If he be attentive, he will see the necessity of closely watching all parts of the plant. Compare all this care and attention absolutely required by a direct lighting plant to that heretofore supposed to be required by a secondary battery doing exactly the same amount of work.

How is it possible to place a battery in a damp cellar, and with little or no attention expect it to do satisfactory work at the rate of 25 h. p? Batteries as now constructed have an E. M. F. of 2 volts and an internal resistance varying with the number of plates per cell. Given a battery of 100 cells (3 h. p.) we have a total E. M. F. of 200 volts and an internal resistance of $\frac{1}{30}$ ohm. With this comparatively high potential and low resistance what is to prevent a constant loss of current by creeping, if such a battery is located in a cellar, and covered with dirt and moisture? I have seen batteries working under such unsatisfactory conditions. On account of its great weight and the fact of sulphuric acid being used, it is best that the battery should be placed in a cellar—but the cellar should be dry and clean and well ventilated.

The first and most important point to be observed is to carefully insulate the cells from each other and from the earth. The plan I have adopted is to use 4x4 scantling well painted with asphalt varnish—the scantling is insulated from the earth, by the ordinary pin and glass, the glass being inverted and kept filled with paraffin oil. On the scantling are placed large porcelain insulators, four for each cell—on which the cells are set—the cells are kept one inch apart, so as to allow a free circulation of air around the boxes which keeps them dry. As the tops of all the boxes are on the same level, and about three feet from the floor, they can be easily examined. A reliable volt-meter and hydrometer should be provided so that each cell can be tested every day or two, to discover if any one is becoming faulty. Sometimes a square of active material will drop out, and lodge on the positive and negative plates, making a circuit of comparatively high resistance between the two, which will in time completely discharge the cell. A test with a volt-meter will indicate a fall of potential, and the hydrometer will show a fall in the strength of the acid solution in a cell so troubled, and the cause may be removed in a few moments. A fault of this kind will probably be understood when it is explained that the plates of a secondary battery contract when being charged, and expand while being discharged.

If the correct strength of solution has been used when the battery is first set up, a good hydrometer will also indicate the amount of current that has been taken out, which should not exceed 85 per cent. of the capacity.

Right here I would remark that within certain limits it is impossible to overcharge a battery—but it can be completely destroyed in a very short time by over-discharging. During discharge sulphate of lead is formed, and that is the destroying agent in secondary batteries.

In conclusion, I wish to emphasize the assertion that secondary batteries have passed beyond the experimental stage. They must, however, be properly constructed; they must also have a capacity proportionate to the work they are intended to do. Such a battery can be placed in the hands of any one of ordinary intelligence, who, if he follows instructions and will give it the same amount of attention required by mechanism doing the same quantity of work, will meet with little or no trouble; on the contrary, the battery will be found always ready to furnish current at its maximum potential.

The President: During a recent visit to England I found that the introduction of secondary batteries had apparently progressed a good deal beyond anything we had in this country, as far as I knew. There were a good many installations working in various places, in factories, houses, one place and another, and so far as I could learn, on inquiry, with very good success as a rule. I was somewhat surprised to find they were doing so much, better than we had been able to do in this country, so far as I could learn. But Mr. Bauer's paper informs us that he is getting results that are equal to anything that I have heard of or seen anywhere. It simply shows that if proper care and attention are devoted to the question that the secondary battery is a practical and commercial institution.

Mr. Mailloux: I have been through the storage battery pretty thoroughly, and I have been through several phases of opinion regarding it. When it first came out I was enthusiastic about it, the same as was nearly everybody else. After a while my enthusiasm cooled, because I was connected with it practically, and I found that it worked a good deal better on paper than practically. Perhaps for a year I almost totally lost my faith in the storage battery. But as the subject received the attention of proper talent, and as the causes of its imperfections were investigated, I have begun to see my way a little more clearly into the possible success of it, and I have begun to feel a little more kindly toward the storage battery, and although I had another relapse from my good standing, I may say that now I believe the storage battery has come to stay. I believe that we are going to see the storage battery in this country assume a more interesting and a more important part in installations in which electricity is used. As the paper shows, nearly all the difficulties which have been considered as inherent in it, and not the least one of those is the formation of the sulphate of copper, have been overcome, and when we have got the storage battery as we have it now, so that power can be stored in it and be allowed to remain stored for a long time, as much as five or six months, then I believe we have got a practical thing; I do not think there can be any longer any doubt, as there are batteries which are accomplishing that, and they are being used with a great deal of success, so I believe that it is about time that we should undergo a change of opinion and think a little more kindly of the storage battery.

Mr. Shelbourne: I think it would be interesting to know from members of this Institute the business condition of this storage battery. If I recollect right I think Mr. Preece, during the fall of 1884, at the Philadelphia Exhibition, threw out an idea something of this sort—he rather scouted at the idea of there being a patent security upon the original storage battery, as I understood. What I am asking is, can the president or any one inform us as to whether there is one basic patent on the storage batteries in this country? I am informed that the Brush company has gone into that subject very extensively, and here we have a paper from Mr. Bauer of Baltimore. I was aware at the time of that battery being brought over by Mr. Bauer, because a friend of mine who was acquainted with him was on the same steamer coming back. I have seen so many claims about this one or that one promoting some storage battery in one section of the country or another, that I think it would be desirable to know whether there is any one source from which they originated, and whether that source is secured by a patent.

THE PRESIDENT: I do not know whether I can give any specific information on that point. The original storage battery is that of Planté, and there is no patent on that now in this country, and I do not think there ever has been. The improvement that was made by Faure was in the application of the substance to the plates, and that, I think, was the subject of an interference in the Patent Office which was awarded to Mr. Brush. I may be wrong about this; I have never given the subject any particular attention. It is possible Mr. Fowler may be able to give us some information on it.

MR. FOWLER: I am sorry to say that the secondary battery is a subject I have had very little to do with.

MR. MAILLOUX: I think you are right, Mr. President. There was a long controversy waged between several contending parties, and I was brought in as expert in favor of one of the contestants. It occupied several years, and there were some four or five inventors in this country interested. There were at least three or four who were interested in the suit, and the issue was, I believe, on the right to apply some salt or compound of lead in a disseminated form, as distinguished from the battery of Planté, in which the pure sheets of lead are used and a spongy formation is made by the current itself. In the Faure battery we also find that the oxide is made separately, or else that spongy lead is prepared and applied to that sheet of lead, which is so arranged that it has retaining cavities which will hold it. I have not had anything to do with the suit for nearly two years, but I have understood through the papers that Brush had come out first in the interference, and that a claim had been granted to him covering broadly the extraneous application of lead and lead compounds to a piece of lead forming the plate. In other words, I should understand that to mean, that although it is open for anybody to make storage batteries by using pieces of pure lead and forming them directly, that anybody who attempts to make a storage battery by taking lead plates and applying any mixture of lead to them is liable to infringe the patent.

THE PRESIDENT: That accords with my understanding of the position, which I did not present with any great confidence, because I thought I might be mistaken about it.

Mr. Mailloux: Mr. Wetzler here, of *The Electrical World*, could probably give some information about it, because I know something was said in that paper about it at the time.

Mr. Wetzler: All I can say is that that patent was issued last January or February, and the essential point covered by it was the mechanical application of an actual material to the lead plate of the storage battery.

The President: Then it would seem that the modern storage battery is controlled by that patent. You will perhaps remember that Mr. Preece, at the Franklin Institute exhibition at Philadelphia gave an account of a private plant of his own which he used to light his house, worked by a storage battery and a gas engine. I was at his house in February and examined that plant, and it was working very satisfactorily indeed with the same battery with which it was originally set up. But while I was there he changed it, not because the battery had given out, but because he wanted to enter on a new series of experiments with another make of battery, and so he took down the one he had been using from the beginning and took it to the Central Telegraph Station in London, and fitted it up for working a telegraph line, and he has just started on a new battery at his house. Mr. Preece is making tests two or three times a day, and keeping a very careful record of the performance of the battery, which will ultimately form the subject of a paper I have no doubt, and will be of very great importance in the way of giving information as to what results are obtained and what are the causes of them.

Mr. Mailloux: There is one point that comes to my mind in connection with the paper of Mr. Bauer, and that is regarding the use of a hydrometer as an indication of the strength of solutions. I know very well that scarcely any well-regulated establishment is without a hydrometer, but unless they have had better success with it than I have, I do not think that its use is to be recommended. I do not think that the hydrometer is a very sure indication. It is a sort of guess-work, but I do not think that as an instrument of precision it ranks very well as a means of estimating the strength of a solution. While I was at work, particularly with copper solutions in Chicago during the last year, I was led to abandon its use entirely. To give you an idea of my experience in that respect, I have made say two different solutions that would both indicate about twenty-four degrees Beaume, and yet one solution would have a specific gravity about ten times greater than the other. The point was merely this, that in one case you had the same density in both—but in one case a part of that density was due to the presence of free acid, and in the other case it was due to the presence of the salt dissolved in greater quantity, and although they both had the same density, yet so far as their efficiency was concerned, either from the standard of free acid contained or the standard of resistance, they were totally unlike. So I found there was no reliance to be placed on it. I could not tell whether it was the kind of solution I wanted, though it might give the proper indication, and I found that the only reliable way was the acidometric test, by some means of estimating the amount of acid and the amount of salt in solution. That gave invariable results.

The President: It would seem from what Mr. Mailloux says that the hydrometer should be relegated to the same region as the voltameter and many other of our cherished delusions.

Mr. Maynard: I would not undertake to say anything about what the patent rights on this question are, but judging from the number of inventors about Washington, I should think the woods were full of them, very much as in the case of the telephone. Before the question is settled there probably will be a good many persons to be heard from. I happened to see the first of the experiments Mr. Bauer reports there in running street cars. The trouble was he had so much power that he ran the car and all the passengers off the track at the first move. That was owing to the putting on of too much power, and having an extraordinarily bad track to run on, heavy grade with sharp curves, and all the disadvantages combined.

About the length of time this battery would stand—I did some experimenting with some of these first batteries Mr. Bauer speaks of; not the imported ones, but some made immediately afterward, and made about as badly as they could be, and in a general way the experiments showed clearly that the electrical part of the thing was entirely feasible, and that after experimenting with this for about a year I had occasion to move the cells from the building where they were, and to stop the experiments. I left five or six of the cells which appeared to be the best ones, and they stood about four months in a damp cellar, and at the end of that time we had to capsize them, and they seemed to be about as good as ever they were.

Mr. Fowler: While I don't know very much about the foundation patents, I know there are about a dozen cases in the Patent Office now, just on the question of secondary batteries. Whether any have this foundation claim in them I am not informed. I know there are about a dozen cases of interference in this one matter.

MR. SHELBOURNE: As I understand it, Mr. President, such a battery as Preece is using now in his house, I should think is the one that he described at Philadelphia in 1884. As I am informed, such a battery as that may be used in this country without reference to any patent. It is one that everybody can use. This interference that was decided in favor of Brush, I understand, is for the mechanical application of an active agent to the lead plate. As I understand, Mr. Preece's battery was composed of lead plates themselves of a certain construction—spongy condition, or something of that kind.

THE PRESIDENT: The battery which Mr. Preece talked about was one thing and the one he uses is another. He uses the battery of the Electric Power and Storage Company; I think that is the name of it. That is one form. The other form is one made by Parker of Birmingham. I think they are under the same patent, but there is some difference in them. Both are made by the application of this salt of lead to the plate, and not according to the original form of Planté.

MR. MAILLOUX: If that patent is construed to mean the mechanical application of active material to the lead plate, I do not think it is essentially a very broad patent. But there is another way of applying lead to a plate, and it was in that way I made the first storage batteries I was called upon to make, that is, the electrolytic application; by taking a plate of lead and depositing lead upon it in a spongy form by electrolytic action. The originator of that idea was undoubtedly Mr. Keith, formerly Secretary of this association, and he conceived the idea in connection with his process for refining lead. At any rate, the first batteries that he produced were made in that particular way by taking plates of lead, perforating them suspending them in a solution and depositing lead upon them electrolytically. I doubt very much whether the Brush patent simply confines itself to that, because I know this point was gone over very fully in the evidence brought before the Interference Commission, and I have no doubt they made very strenuous efforts to cover that part of it. It is indisputable that you can make excellent storage batteries that way, so that unless the patent does cover that mode of doing it, it is not without a loop hole, at any rate.

The President: I don't know that I ever looked at the patent carefully, and I cannot say whether it covers merely the mechanical application of the material, or the application of it in any way. It might well cover the application of it in any way if he was the first to do it, and in connection with this subject I might say that some years ago I came across a very excellent description of the storage battery in a patent by a Mr. Charles Kirchof of Newark. I think it must be twenty or twenty-five years ago that it was granted. I have not had occasion to look at it lately, but it struck me it anticipated a good deal of what has been done since. Possibly Mr. Fowler may remember it.

Mr. Mailloux: Mr. Kintner has recently read a paper before the Franklin Institute, where he refers to that fact, and mentions the great importance of that Kirchof patent, which appears to have been entirely overlooked. It seems to cover many points since brought out as original.

Mr. Wetzler: I received that patent from Washington the other day, and was much astonished to see, as Mr. Mailloux says and Mr. Kintner pointed out, that many ideas are in that that appear to anticipate more recent inventions. For instance he perforates his plates. He ruffles them also by pressing them between sand-paper, and he uses other means of that sort. It is a very interesting document. He uses the usual Planté process of formation, as it is called.

The President: Is there any one present who knows anything about the history of this Mr. Kirchof of Newark? I am quite suprised at the fertility of the man's mind. He was one of the old pioneer inventors, and the germs of a great many modern inventions are found in his work. In looking it over I found at different times a good many things that have since developed into matters of importance. I think one of the first unisons for bringing step-by-step instruments into synchronism was in one of his patents. Then we find quite a perfect form of the multiple call-box, for sending a variety of signals from one box, and various other things of that sort. He was quite a remarkable man for the time in which he lived, and I have never happened to learn anything about him, as to who he was and what his history was.

Mr. Mailloux: I think I know a little about it, because I am acquainted with his son. Mr. Kirchof originally came from Germany; he was a man of excellent education, being a graduate of one of the universities there, and I think he is now a translator of languages. Mr. Charles Kirchof, who, I think, is his son, was editor of the *Engineering and Mining Journal* for a number of years, and is now on the editorial staff of the *Iron Age*. I think that is his name. I think Mr. Kirchof lived in San Francisco at one time, and he has done a good deal in mining as well as in other scientific matters. I have read of him a great deal, and he is known to be a very well-informed scientist. I think he is also related to the discoverer of Kirchof's so-called Laws of Electrical Currents.

Mr. Wetzler: I wish to rise in order to contradict the statement that Mr. Mailloux makes. I was acquainted personally with the gentleman that he speaks of and with his son, but that was not the Kirchof the President inquires about. The original Kirchof is dead. I happen to be acquainted with his widow, and I have often looked over his old instruments and books. It may not be uninteresting to note that he made a number of inventions outside of electricity. Among other things he invented a device for attaching candles to the Christmas trees, and his widow supports herself by manufacturing those articles now.

The President: I think it would be an excellent thing for some one who has the material accessible to prepare a sketch of that man's life and works. He is a man who deserves to be better known to the profession.

Mr. Mailloux: Mr. Wetzler is the man.

The President: Mr. Wetzler I hope will be able to do it. I hope he will be able to give us a paper on it. Nothing is more interesting than biographical sketches of some of our pioneers in these matters. I think sometimes, as the saying is, some of them have forgotten more than ever we knew. Take such men as Professor Henry and Moses G. Farmer, very little of the work they have actually done has ever been published or made known. There are a good many other men in the same category. Some of their names even are unknown to the present generation of electricians, and it would be a good work for any member of this society who is enabled to get hold of any information of that kind to bring it forward and get it into our records and have it preserved. Those men did valuable work, and they ought not to be forgotten.

Mr. Shelbourne: I hope Mr. Wetzler will be able to introduce a picture of the gentleman in the *Electrical World*, so that we may know how he looked as well as what he said, because I think it is quite an important addition to what people say, to know how they looked.

Mr. Wetzler: I will say that I am well acquainted with his widow, and she has given me access to his books, and if I can go about it, I shall do so at the earliest possible moment.

The President: I sincerely hope you will improve your opportunities.

If we have no further discussion on this paper, I would ask if the Committee are ready to report on the subject of wire gauge.

Mr. Mailloux: The Committee has met together and discussed the subject, and gone over the ground with the assistance of Mr. Pope, who has all the material, and has formulated the following resolution by way of report:

"*Resolved:* That the Standard Wire Gauge adopted by the English Board of Trade, be and is hereby approved, and that the American Institute of Electrical Engineers recommends its adoption for the following reasons:

1. It is desirable to secure uniformity in standard measurements wherever possible.
2. That the adoption of the S. G. W. is an important step in the direction of such uniformity.
3. It has been legalized and passed into current use in Great Britain and the colonies, France and Germany.
4. It is arranged so as to equalize as much as practicable the want of uniform gradation between sizes as found in other gauges."
5. It has a range in sizes which appears to comprise the extremes of large and small sizes likely to be used."

Mr. Mailloux: And we might add the further reason that it has received the sanction of the other associations, the National Telephone Exchange and the National Electric Light Association, and that several manufacturers in this country have manifested their willingness to go by it altogether if it is accepted.

Capt. Michaelis: This is a very important subject, and it is one, I think, we ought to hasten slowly about. This is an attempt to get an exact standard of measurement. It not only applies to the wire gauge, but it applies to everything else. The wire gauge is used for all sheet metals, and we know how they vary it. We work under the Stubbs, the old Birmingham, the new British, the Roeblings', the Pratt and Whitney, and I suppose there is no doubt there is a demand that there should be some one gauge which could be easily introduced and could be used as a standard. I think this Institute should do its share and exert its influence to bring about its establishment. I think the simple passing of a resolution like this would hardly have the effect that perhaps a more mature discussion with kindred societies, such as the Civil Engineers, the Mechanical Engineers and other institutions of that kind would have, and I have no doubt those other societies would cordially join with us to bring about on the question of guages exactly what the Franklin Institute some twenty-five years ago did in regard to the establishment of standard screw threads, etc., and I would suggest whether it would not be advisable that this matter be referred to the Council, or that a committee be appointed, or this committee be continued, with authority to consult with committees of other societies who might be invited to appoint committees to act with it. It has been done in other matters in regard to the formation of a common library, and I have no doubt the other societies would cordially unite with the Institute in attempting to bring about a standard gauge. I suppose the best way to obtain that is by governmental influence. I know that in government work we have been compelled to do away with naming sizes; for instance, in the inspection of rings for guns. We make rings. We call one a maximum ring and the other a minimum ring and furnish a rod, and say that is the standard rod for the maximum ring, and that is the standard rod for the minimum ring. I merely throw out these remarks as a suggestion. I think it is a very important matter, and I think the Institute ought to use its influence in bringing about a standard gauge of measurement, not limiting it to wire.

Mr. Mailloux: I very heartily concur with the remarks made by the gentleman, and I do believe that we ought not to have one gauge for sheet iron, another gauge for sheet copper, another gauge for copper wire, and another for telegraph wire, as we have been having; yet, if there is anything to be gained by delaying action on it, I should be in favor of delay. At the same time, it strikes me that as the other electrical associations have already concurred in the use of this gauge, and adopted it officially, that our delay could not make much difference in the electrical part of it. We might let the report of the committee go over until some time later, and meanwhile see if we could secure concerted action with the other societies; but it strikes me there would be a great deal of time lost in the operation, and we do not expect that our decision will be final. We do not expect we are going to stipulate what gauge shall be used through the land, but we have taken one step, that is to affiliate with other societies who have adopted the gauge.

Capt. Michaelis: I noticed that the last edition of Nystrom's handbook gives what is called the new British gauge. He gives it in inches. The committee report that it is used in France. I would like to know whether it has been translated to metrical measurements there and what valuation has been given to the metre. That is one of the mooted questions now. I think the value of a metre is hardly yet determined.

The President: They have got nearer to it than you can draw wire I guess.

Capt. Michaelis: I know. But I want to know whether the French scientists make any attempt to reduce this gauge—whether they attempted to deduce it originally on the same process determined on in England, or whether they simply translated the English measures into millimetres or centimetres.

Mr. Mailloux: If I understand right, they simply translated it.

The President: If I understand it, the original construction of the gauge by the English had some relation to an empirical basis.

Mr. Shelbourne: It seems to me that the argument that was advanced here by somebody, that because the different European governments have adopted this standard gauge, and because the National Electric Light Association and the National Telephone Exchange Association have adopted it, that therefore this Institute ought to adopt it at once, else we would appear to merely fall in and adopt something that is already in use, is not an argument that ought to be given much weight. If we fall in and adopt this standard gauge at once, it certainly will appear in the reports of our action that we have adopted it as a matter of course, and without any concerted action with other societies, and without any elaborate consideration of its merits *per se* among ourselves, and as coming to the same conclusion as the results or our own judgment. Now, I have no doubt but that it would be advisable to adopt it in the end, but I think this Institute would get more credit by holding the matter under discussion and consideration than it would by just falling in *pro forma* with the opinions or decisions of the other institutes and associations that have adopted it. It has always seemed to me from the very first time that I came to consider wire gauges, to be a matter that was wrong end foremost; there did not seem to be any basis of reason in the way these gauges were arranged. Now, why should they have a lot of naughts, one or two or three or four naughts put down at the end of a gauge to indicate the largest sizes? I suppose it is because they started at one, and when they wanted larger sizes than that, they went down and indicated the other way. Now, why is it not in accordance with our ordinary ways of thinking and the ordinary notation of things in mathematics to go the other way, to reverse the system entirely? Why say No. 42 for the very finest wire, or why say No. 20 for another wire, or why say No. 16 or No. 12 or No. 8 for a larger wire? Why not put this thing in the relation of thousandths of an inch, and turn the scale end for end? If you want to commence with a fine wire, commence with as many naughts as you choose. But suppose a scale was arranged on the basis of thousandths of an inch, and we wanted to give them numbers. Now, if we make a gauge of which the highest number will be a half-inch in diameter, that would be represented by five hundred-thousandths of an inch. Now, suppose we commence at 1, and the finished wire would be one-thousandth, the next size would be two-thousandths of an inch, and the next size three-thousandths, and go on in that way up to five—up to ten, if you like. But where you get to the medium sizes, where such a little difference in diameter makes such an appreciable difference in the circular section, make the steps at five-thousandths. Then what will we have? We will have a gauge that will be composed of 105 divisions or steps, of 105 different numbers. First, there will be 1, 2, 3, 4, 5. There would in those sizes perhaps be too much difference between five-thousandths and ten-thousandths; you might make other divisions up to ten, if you choose, but you would get then the finest wire perhaps that would be practicably useful at a thousandth of an inch. A finer wire than that might be called hair wire. You would get the largest wire a half-inch in diameter, and when you go above that you might call them rods or bars. I do not put that down as an exact description, but upon some such basis as that we would get a gauge that would conform to rational ideas of numerical notations and sizes.

THE SECRETARY: I am not a believer in the policy of undertaking a thing of this kind and ignoring what has been done before and done very carefully, and going to work and doing it all over again just for the sake of saying we have considered the subject. This is a subject that requires very deep investigation in order to do it very thoroughly, and if we undertake to do that we have a pretty good contract before us. We have the records of what has been done, and we have the calculations elaborately worked out, and we can get all the testimony in regard to this matter that has been brought up in England. It was not accessible to-day, but it is in existence, and I do not think that under the circumstances we could be accused of undue haste simply because we did not go into all these calculations and investigations ourselves. It would be a matter requiring considerable time and considerable money, and, judging from my experience in the working of committees, it would be very doubtful whether we arrived at any conclusion, and if we did, if we attempted to introduce a new gauge or opposed the adoption of a standard gauge that had already gone into universal use, we would simply be putting ourselves on record as undertaking to do something that it was utterly impossible for us to accomplish. The movement has started, and whatever else may happen, we shall eventually be obliged to fall into line. The train has started, and we may as well jump on. It appears to me that we will save time and save words by taking it for granted that these gentlemen who have investigated this subject have done it conscientiously, because they felt, just as some of these gentlemen do now, that it is a matter of importance and should be thoroughly investigated, and they have done it. They have done it probably in spite of the opposition of various manufacturers who have gauges of their own that they wished to stand by as a matter of sentiment, and where so much has been accomplished in the direction of reform, it appears to me, as has been well said before, that it is better to have one standard, even if that standard is not a perfect one, than to have half a dozen poor ones with perhaps one good one amongst them. It is the multiplicity of the gauges that has been the great evil rather than the inaccuracy of any of them. There lies the merit of this movement to reduce the thing to one standard, and for that reason the action on the standard gauge has made what progress it has made, simply because people want to do away with that multiplicity of gauges and get the thing down to one standard.

Capt. Michaelis: Some years ago Brown and Sharpe promulgated, if I may use the term, what is known as the Standard American gauge, which was an attempt to soften the asperities of the Birmingham gauge, and to give the gauge a geometrical foundation. I have not heard what the objections were to it. I know it is not generally used by wire manufacturers, and yet wire manufacturers will use any gauge. I heard probably the most distinguished wire manufacturer in this country say that he would draw wire to any gauge he is asked to draw it to and paid to draw it to. If we are to have any gauge, it seems to me we ought to have a gauge founded on some reproducible mathematical basis. I would like to see a gauge from which, giving the size of No. 31, I could deduce the size of No. 30. You cannot do that from the Birmingham gauge, and with the new English gauge you cannot do that, because there are hiatuses in the construction. I do not know what the foundation is. Mr. Mailloux and myself have just talked it over. I see no intrinsic objection to having a gauge that could be calculated by any one. The gauge ought to be so arranged that if you know the extremes you can reproduce the intermediate numbers. I do not object to the new English gauge at all, but it seems to me it is a very important matter to commit the Institute to. I think we ought to have a wider and broader expression of opinion in regard to the matter. It seems to me that the matter might be confided to the Council, or that this committee might be continued, and that whatever recommendation they came to, be submitted by letter ballot to members, instead of having a score of us decide the matter.

Mr. Mailloux made a sketch upon the blackboard showing the basis of the construction of the English standard gauge.

Capt. Michaelis: I think, if you adopt a new gauge, it should be one that is founded on some mathematical curve or law.

Mr. Mailloux: I think, Mr. President, that Capt. Michaelis's idea of a gauge founded on some conic section curve has in it the elements of practicability. In other words, it seems to afford that width of range—that difference of range which is evidently desirable between the first part of the scale and the other part. At the beginning, at the lower part of the scale—at the first low numbers, we want a considerable difference between the various sizes. While at the small numbers of wire we want an exceedingly small difference, and it looks as though it might be possible to construct a curve—to reduce the equation of a curve even from the standard wire gauge. The standard wire gauge could be taken in hand and under proper treatment it might be made to conform to a curve having an equation.

Capt. Michaelis: I recall an article now that I read in the *Electrician*, I think, in which the writer produced a formula by which, given the gauge number, you could get the size in mils. He plotted the gauge, and I suppose attempted to reconcile differences. That was in one of the older gauges, and then he did get a formula, introduced certain constants and found a method that approximately gave him the number of the gauge if he had the wire, or the diameter of the wire if he had the number of the gauge. If your gauge were founded on some mathematical curve, you could extend it to the minutest differences, because you can draw curves that will approach their asymptotes either rapidly or slowly. Knowing that curve, all you would have to do would be to substitute either the values of the ordinates or the diameters.

Mr. Mailloux: It strikes me that the idea that is presented by this gentleman is very feasible, and although I was in favor of adopting the standard gauge through thick and thin, I think it would be well enough to wait awhile, and see if he or some one else could not suggest something that would be an improvement over the standard wire gauge. I think, at any rate, that the gauge, as now made, can be taken in hand and made to conform to what he suggests.

The President: This brings us back to the original question, however, whether it is better to adopt a gauge that is theoretically imperfect, but seems likely to come into very extensive international use, or whether we shall adopt one that is in some respects better but which will leave us with two or three different kinds of gauges. It is a matter that I, myself, think ought not to be hastily decided, and I agree with Mr. Shelbourne, that it is perhaps of no very great consequence if we do not start with the procession.

Mr. Wetzler: I move that the resolution be adopted.

The motion was seconded by the Secretary, who then read the resolution.

A *viva voce* vote was taken, but the Chair, being unable to decide whether the ayes or the nays were in the majority, called for a division. Mr. Mailloux arose at this point and offered as an amendment to the motion of Mr. Wetzler that the report be put over until the June meeting. The amendment was accepted by Mr. Wetzler.

CAPT. MICHAELIS: Is there a June meeting?

THE SECRETARY: There is a June meeting of the Council.

CAPT. MICHAELIS: I would suggest that the subject be referred to the Council, with power to consult with other societies, and formulate an expression of the opinion of this Institute.

This was accepted as an amendment by Mr. Mailloux, and adopted.

MR. MAILLOUX: I would like to move that a committee of one, consisting of Capt. Michaelis, or, in other words, that Capt. Michaelis—

CAPT. MICHAELIS: I call the gentleman to order. He is interfering with the prerogatives of the President.

MR. MAILLOUX: That is all right. I move that a committee of one be appointed by the Chair. My object is—if I can state it before putting the motion—that I would like to see Capt. Michaelis present his ideas a little more fully in regard to means of improving the wire gauge or modifying it so as to make it mathematically elastic, so to speak. I think it would be well for a committee to be appointed to look into what can be done by way of improving the standard wire gauge. I do not think that it ought to take very long to go over that ground, and I think the committee might be able to bring in very valuable suggestions and put the matter in such a clear light that we might be practically in the way of putting before the public a gauge which would be so little different from the present gauge that it would not be met by much hostility.

CAPT. MICHAELIS: I second the resolution of the gentleman. I have been struck at this meeting with the fact that we have in the Chair a gentleman who is better versed in parliamentary rules than the majority of the presiding officers at any of these meetings, and with my abiding faith in his knowledge of parliamentary law, I unhesitatingly second the motion of the gentleman.

MR. SHELBOURNE: I desire to say in regard to that motion that it is not only unparliamentary but entirely out of order. By a motion that has been acted on, this matter was referred to the Council with power. Now, the motion of the gentleman is that a committee of one be appointed to bring into the meeting or to the Council some mathematical suggestions in regard to this thing. Capt. Michaelis is a member of the Council. Therefore, the value of Capt. Michaelis's suggestions here to-day will be apparent when the thing comes to be considered in the Council, and I think if there is any occasion to make a committee of one the Council will be able to do it.

Mr. Mailloux: I must beg the Chair's pardon, and that of the meeting as well. It would appear that I know as little of parliamentary rules and proceedings as anybody. I was not aware that I was sinning against any rule. If I have, I beg pardon.

The President: You cannot know less about them than the Chair, but it would seem, from a common sense point of view, that Mr. Shelbourne's point is well taken.

A Member: There is lying, unacted upon, a resolution in regard to Past Presidents, and also in regard to monthly meetings.

The President: I think the question regarding Past Presidents was settled, but the committee on the question of monthly meetings has not reported, I believe. We are ready to hear from them now.

The following was presented by the Secretary as the report of this committee:

"The committee on monthly meetings respectfully report that they consider such an arrangement desirable, and recommend that they be authorized to formulate a plan for such report, subject to the approval of the Council. In the judgment of the committee it would seem advisable that these monthly meetings be held at the same time and place as the Council meeting, and they would recommend that the next Council meeting, on the first Tuesday in June, be set as the date of this first meeting, at which the committee can then report on a more detailed plan.

G. M. Phelps, Jr.,
C. O. Mailloux,
R. W. Pope."

"*Resolved:* That the committee on monthly meetings be and is hereby authorized to make arrangements for such gatherings as may be considered for the best interests of the Institute, and their action be reported to Council at its next meeting for approval."

Mr. Shelbourne: Would it not be necessary, technically under the form of the resolution, that it be referred to the Council, and be made subject to their approval, because, if we authorize this committee to do certain things, and they report the thing to the Council, the Council would feel, you might say, instructed as to their duty by the vote that we now take. Is this matter subject to the Council's approval, or do we give it a final approval here?

The President: As I understand it we give it approval here, and the Council are to decide on the particular manner of carrying it out.

Capt. Michaelis: I happen to have an intimate knowledge of certain questions of the Constitution of the Institute, for the reason that I was present at the meeting when they were amended. I think it very well to have monthly meetings, but you can only reach them in one or two ways, without an amendment to the Constitution. They can only be held as special meetings, unless they be social gatherings and do not partake of the formal character of authorized meetings where business can be done. The Constitution provides that meetings may be called in two ways: by the Secretary on the written request of fifteen members; or the Council may call a special meeting. This committee can only make recommendations, and then either have a call signed by fifteen members of the Institute and presented to the Secretary, who would then call a special meeting, or they might recommend to the Council to call a special meeting at such a time as they saw fit, but that is the only way. This meeting cannot provide for the monthly meetings. In fact there cannot be monthly meetings until the Constitution is amended. There can only be special meetings called in the manner indicated. I do not desire to make any point about it at all, but only to state what the constitutional provisions are.

The President: It would seem, if Capt. Michaelis is right, and I presume he is, that no particular action is needed about it; that the Council are quite competent to order these meetings if they think it desirable to do so. So, in that case, it would seem to be only necessary, as to our present action, to recommend that the Council do it.

Mr. Shelbourne: That is the very point I wanted to raise. If you make this committee report subject to the approval of the Council, and not decide the approval here at this meeting so as to instruct the Council, but make it subject to the approval and in the discretion of the Council, then the Council can call these special meetings.

The Secretary: We were fully aware of this provision of the Constitution, and it was our intention to comply with the requirements in obtaining signatures, not only that, but to have a contract, as it were, from the required number agreeing to be there in order to make a meeting. This is merely an effort, I may say, on my part, to carry out the ideas suggested, and get something done when we are together to-day, instead of separating and not doing anything more for a year, perhaps.

Capt. Michaelis: I think that is a capital idea, Mr. Secretary. Are there fifteen members here, or is there a majority of the Council here?

The Secretary: There is a constitutional quorum of the Council here.

Capt. Michaelis: When does the Council meet?

The Secretary: The first Tuesday in June.

Capt. Michaelis: Why should not that quorum of the Council now decide to call a meeting on the first of June, and give all here present notice that there will be such a special meeting.

Mr. Mailloux: Can the question of Constitutional amendment be brought up at a special meeting?

The Secretary: The rules may be amended at any regular meeting by a two-thirds vote of the members present, provided a written notice of the proposed amendment shall be given at a previous meeting.

Mr. Mailloux: And there cannot be any constitutional amendment made until next year.

The Secretary: There are two other regular meetings to be held as appointed.

Mr. Mailloux: But we cannot, under the Constitution, make an amendment until the thing has been proposed in writing.

Mr. Shelbourne: This committee is not ready to formulate the details, and how can the Council act upon some thing which is inchoate, and as this meeting of the Council is to be in two weeks from now, which, as I understand, is the very first day of June, and we are now at the 18th of May, I do not see how, even if we could carry out the view of the Secretary or of the Committee, any action could be taken at the present time so as to have a special meeting at the same time and at the same place as the meeting of the Council on the first Tuesday in June. If they are to formulate a plan and report the details to the Council, then the plan cannot go into existence before the Council considers it, and that will be the first Tuesday in June. Then we are coming into the summer, and the question is, when can we have monthly meetings after that, whether approved by the Council or not, or whether called by the Council, or whether called by the Secretary upon the request of fifteen members. Of course I believe in these monthly meetings, and I believe in organizing them and carrying out that plan as soon as practicable. But we are just on the edge of summer, when everybody goes out of town, and people prefer to loll on verandas with palm-leaf fans in their hands to getting together in meetings. I think that if we are going to have undue haste in this matter, perhaps we will defeat the very object we are trying to promote.

The Secretary: Mr. Shelbourne has brought up the very point in regard to it that I mentioned in my report, that is, that unless we have a meeting the first of June, it would be well to lay it over until autumn, and it was for that very purpose it was brought up, that we might have simply one in order to start it before summer, for fear that so long a time would intervene before the next one, that instead of undue haste we would have undue negligence, perhaps.

Mr. Shelbourne: Let the Council now call a special meeting. They can do so.

Mr. Mailloux: If they think there would not be time enough before the first of June they could call the special meeting for some other time in June.

Capt. Michaelis: I am sorry to say that a meeting cannot possibly be held on the first of June, because the Constitution provides that at least twenty days notice must be given to every member.

The Secretary: That is what the Constitution says, but I am sorry to say that it is not carried into effect, for if you send notice too far in advance members forget it, and consequently it has been the practice not to comply strictly with that provision. This is not a personal matter with me. I do not care anything about it at all personally. It is merely a matter for the good of the Institute. People ask me, and members ask each other, if the Institute is alive, and so on. These questions are coming up—here is this wire gauge question. We could talk all night on that, I suppose, if there were not any special business, and I feel very certain that it is important for the welfare of the Institute that something of this kind be done. But whether it is done now or whether it is done next year, it makes no difference to me. I simply recommend it for the good of the Institute. There will be less work for me if it is not done. I do not object to the work, but I want to arouse a little sympathy in its execution and feel an interest in it which I cannot do if we allow things to lie over for a year or six months. If we proceed in that way the Institute will drift along and nothing will be accomplished.

Capt. Michaelis: I give notice now—I suppose it ought to be in writing, but perhaps the stenographer's notes will be taken as writing—I give notice now that at the next special meeting of the Institute to be called as provided in the Constitution, I propose to offer an amendment relative to more frequent meetings of the Institute, and also to define what business shall be done, and what powers shall be exercised at such meetings. I do that under the constitutional provision that these rules may be amended, provided that written notice of the proposed amendment shall be given at a previous meeting.

Mr. Shelbourne: The question before the Institute is upon the adoption of the report of the committee, I believe.

The President: Yes, I believe that is the question.

Capt. Michaelis: I move that the report of the committee be accepted, and that the committee be continued.

A Member: I think it will conduce to the life of the society and its best interests to have an informal meeting called. Let the Secretary send to the different members and get them together to discuss the feasibility of holding such meetings.

The motion to accept the report and continue the committee was carried.

The Secretary: I will merely say, Mr. President, that in doing this we will endeavor to comply with the requirements of the by-laws.

Capt. Michaelis: It is thought feasible to have another meeting before summer. Do you think we could get a large meeting in June?

The Secretary: Not a large meeting.

Capt. Michaelis: A representative meeting?

The Secretary: Yes, a representative meeting here in New York.

Capt. Michaelis: Then, I think it proper that the Council should call another meeting to be held in New York some time in June. If the gentlemen who know most about these affairs—the President and Secretary—deem it feasible to have a gathering that will be a representative one, I can see no objection to having the Council call some such meeting in June.

The President: There is no apparent reason I can see why the Council should not call such a special meeting and hold it as early as possible in June.

Capt. Michaelis: It would be a regular meeting at which amendments to the constitution could be considered.

Mr. Mailloux: That is the object. The object is to have the society in such shape that it will be legal and proper for us to hold such monthly meetings, and we want to have the plan matured now before the society goes on any further, so that when we come together next fall we shall have a programme to follow out.

The President: I do not know that that requires any special action. It is quite within the scope of the power of the Council. There are enough of them here who understand what is necessary to be done.

Mr. Shelbourne: I don't think an informal meeting, Mr. President, can be called in a formal manner.

The meeting then adjourned.

SUPPLEMENT.

At a dinner and special meeting of the Institute, held in the Mills' Building, 35 Wall Street, June 8th, 1886, among other proceedings the following discussion took place, on the subject of Mr. Shelbourne's paper read at the annual meeting of the Institute, May 19th, 1886.

The President, Mr. Frank L. Pope, in the chair.

Mr. Shelbourne, addressing the meeting, said:—

The matter which I have to present is rather an after affair. It is, perhaps, a supplement to what was said in my paper at the annual meeting; and the reason for it now is found in the fact that, since the annual meeting, there has been published in the *Electrical Engineer*, the concluding portion of the discussions in England, in the Society of Telegraph Engineers, upon the paper by Prof. Hughes, at the annual meeting of that society, when he took the chair as its newly elected President. I want to say preliminarily that what I have to present is written out in order to make it concise and in proper form, and that it is rather tentative. I have formed no definite views, because I have not had time enough to study the subject farther, nor have I obtained the opinion of any other person, except a friend of mine, on the subject. Therefore you may regard it as theory or something to advise me about, or something to think about.

I want to say that I am sorry that Mr. Lockwood and Mr. Seely were obliged to leave to catch the train, because I had hoped particularly that Mr. Lockwood would give us his views on the subject.

[The supplementary paper was as follows]:

Mr. Chairman and Gentlemen:—When my paper on underground electrical systems was read by Mr. Ryan, at the annual meeting on May 19th last, I took occasion to say that I thought the opinion or idea which had been promulgated and urged in several quarters, that iron pipes or conduits caused a retardation, more than other metals or materials, of the electrical currents in the conductors within them, was erroneous and based on no known facts or theories of static induction.

In that paper, I expressed the view that if there were any real differences observed, instead of being charged to the account of static induction, a solution for them might perhaps be found in theoretical considerations of dynamic reactions. I used the word "theoretical," because I did not know at that time of any researches or experiments to confirm my ideas as to the cause of such effects.

I have since observed, on reading the stenographer's report of the discussions on that paper, that Mr. Mailloux touched upon a theory of explanation which tallied in most every respect with the ideas I expressed.

It now affords me a more definite satisfaction to find what I believe to be a strong confirmation of my views, from actual researches and very careful experiments, and that too coming from a most eminent and reliable source.

We have just had printed, in the June number of the *Electrician*, a report of the concluding discussions in the English Society of Telegraph Engineers, upon the very important address or paper of Prof. Hughes on taking the chair as President of that Society. In those discussions, Lord Rayleigh intimated that most of the results of Prof. Hughes' experiments had been foreshadowed by Clerk Maxwell, which, although properly rebuked by Prof. Forbes, only shows to us plebeians on this side of the Atlantic, that even noble and scientific minds are not free from those ungenerous disturbances so familiar to lower toiling mortals.

It was after such observations by Lord Rayleigh, and the close of the verbal discussions in the Society, that the facts came out, of which I wish to speak, in the written reply of Prof. Hughes to those discussions.

The additional researches of Prof. Hughes, given to us in that reply, seem almost directly to confirm the theoretical views I have expressed in my paper. You are all aware that Prof. Hughes' experiments related to what he calls self-induction, or what are commonly known as extra currents in the single identical wire operated upon. Although ordinarily, when speaking of dynamic induction in the telephone, we mean the currents generated in other wires parallel to the one in operation, yet we may fairly recognize that self-induction. as treated of by Prof. Hughes, is nothing else than dynamic induction, more properly considered as dynamic reaction. And so we can see how it may come to have been thought that "retardation" was the right name to be given to the effect, alleged to be observed in telephone lines in iron pipes underground. as though these effects were correctly to be referred to static action.

Now Prof. Hughes' latest experiments have conclusively shown that the difference in the electro-motive force of the extra currents, induced in copper and iron wires of the same length and diameter, under identical conditions, is as 100 to 400 in favor of the copper; but when the copper wire is insulated and placed in a close fitting soft iron tube, the electro-motive force of the extra currents becomes greater than if the copper wire were an iron one; in other words, the electro-motive force of the extra currents in the copper wire is now as 450 to 433 for the iron. These results are to be referred of course to the variable periods of the current employed in the experiment.

Now, in the telephone, we have not only a constant and very rapid succession of variations, but a reversal of line current for each variation, and a dynamic reaction for each impulse in either direction. If now these dynamic reactions are greatly enlarged in electro-motive force, by the active and changing magnetic state of the soft iron very near to the insulation of the conductor, and this magnetic condition of the iron has to be taken on, discharged, and reverse charged, at every change and reversal in the telephone line current, we can see how the sluggishness of the reactions in the soft iron in enlarging the extra currents in the wire, or the self-induction of Prof. Hughes, will cause the sharp variations in the telephone current to be filled up and impeded, by the extra currents, so that the voice becomes, as it were, an attenuated and hollow echo. There would seem, from the similarity of effects, to be much excuse for mistaking such dynamic reactions for the well-known retardation resulting from static induction.

But here comes in the still unsettled question whether iron has inherent magnetism, and whether therefore the circular lines of force, emanating from the telephone conductor, can and do cause an active magnetic condition in the surrounding soft iron, so that the variations of that magnetic state, due to the changes in the telephone current, serve to produce the magnetic reactions by which the countervailing extra currents are enlarged to exert a baffling power?

The recent experiment of Prof. Hughes would seem to throw some light on this question in favor of inherent magnetism in the iron.

Mr. Carl Hering, of the Franklin Institute, says in an able paper on dynamic electricity, that "it is claimed by some that iron merely conducts and condenses magnetism, but has no inherent magnetism of its own. It is very doubtful whether this last statement is correct."

If we assume that iron is endowed with inherent magnetism, so that lines of force acting extraneously to their own source or material of production, instead of being only condensed and conducted through the iron, can set up an active magnetic state in it, then we can understand how the theory I have advanced of dynamic reactions in telephone conductors placed within soft iron pipes underground, can be readily illustrated as founded upon the changes in the magnetic state of the iron, produced by variable or intermittent currents in the conductors, within them. At any rate the valuable experiments of Prof. Hughes have opened the door to the more conclusive determination of this question, which certainly cannot be very long delayed.

I have assumed in this discussion that the contention of those who assert for an iron conduit an effect upon the wires not produced by other conduit metals to be well founded. But no proof has been offered, and the fact is far from being established on mere assertion; for, electricians of experience in testing underground wires, maintain that wooden boxes for conduits give the same effects and no worse or different ones than iron or other metals.

Yet, if the contention be true, it remains only to point out certain conclusions to be derived from the theory of dynamic reactions, when found to be supported upon further inquiry of facts.

The English Government have put down underground wires in small *wrought iron* tubes not over three inches in diameter. Of that size and sort too were the pipes put down in Boston by the American Bell Telephone Co. So also in this city, were the pipes for the telephone wires put down for the Metropolitan Telephone Co. by the Edison people, and so too in the so-called Brooks' oil "system."

If instead of these small soft wrought iron tubes, large coarse and common cast iron pipes had been used, in which the iron contains more of carbon and impurities of silicon arsenic, phosphorus and others, and which is far less capable of the magnetic state, the difficulties of such magnetic and dynamic reactions would largely disappear, both because of the character of the material and from the greater distance in a large pipe conduit, through which such actions and reactions must proceed.

The companies in this city, and particularly the Commercial Cable Co., which put down six inch cast iron pipes, have found no trouble in telephone experiments, from such reactions.

Again, it will be seen that where, as in the underground system of the New York Electric Lines Co., the trunk lines for the telephone are put down in cables of strands of quadruple conductors, and the opposite conductors of the twisted strands form the limbs of a metallic circuit, to be operated with local subscribers ground circuits, by means of induction repeaters at the exchanges, no dynamic reaction can be produced exteriorly in the circuits of such strands, because, primarily, no magnetic state can be created in the iron of whatever character it may be, since each inductive telephonic impulse in the one limb of the circuit is counteracted by an equal one of an opposite tendency in the other limb of the same circuit, and thus, where the iron can get no magnetic conditions, it can be capable of no magnetic reactions.

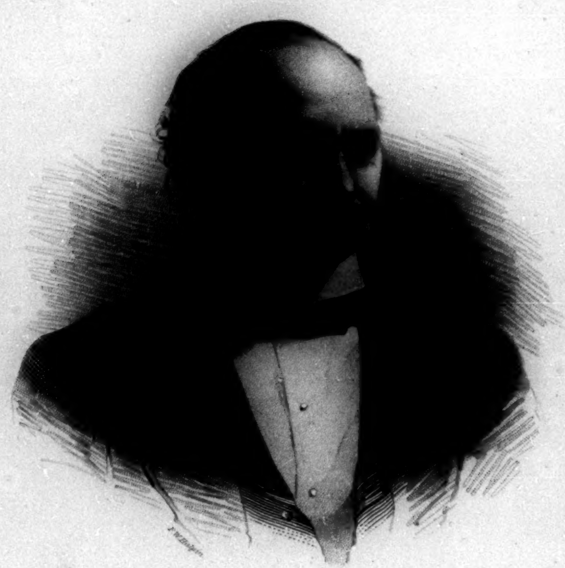
Mr. Shelbourne, after reading his paper, continued as follows :—

Of course the question as to the proper recognition of the existence of the fact, if it be a fact, that an iron pipe exerts an influence deleterious to telephonic currents within that pipe, more than other metals, is an important one. We clearly understand that the iron or any other metal will allow the earth to get that near to the telephone circuit and those actions and reactions which are due to static induction will be just so closely proceeding to the telephone cable or wire as the iron or other metal will allow. That is clear. But if these effects are observed in iron pipes are they not due to dynamic reactions? In other words to those enlarged extra currents which have been shown by Prof. Hughes in his experiments; and if so due, are they due to an active magnetism in the iron or to an active magnetic state which, under the influence of the current, is taken on by the iron, and which reacts upon the current?

Considerable discusion then took place, in which Mr. Mailloux, Mr. R. W. Pope, Mr. Moses, Mr. Hamilton, Mr. Shelbourne, and Mr. Rapieff took part.

The meeting then adjourned.

[The discussions were not reported at length by the stenographer.]



Norvin Green